

Water Quality Technical Workgroup

February 8, 2018, 9:00 a.m. to 12:00 p.m.

Workshop

Missouri Water
Resources Plan

Welcome!

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Water Resources Center

Agenda Overview

- Introduction and Meeting Format
- Missouri Department of Natural Resources Project Vision
- Demands to 2060 for all Sectors
 - Consumptive
 - Non-consumptive
 - Agricultural
- Surface Water Supply Overview
- Preliminary Water Quality Results
- Next Steps
- Public Comments




Missouri Water Resources Plan Vision

- Statutory Responsibility (640.415 RSMo):

"The department shall develop, maintain and periodically update a state water plan for a long-range, comprehensive statewide program for the use of surface water and groundwater resources of the state, including existing and future need for drinking water supplies, agriculture, industry, recreation, environmental protection and related needs."



A dynamic background featuring a large, high-contrast splash of water in shades of blue and white, creating a sense of movement and freshness. The water droplets and ripples are captured in sharp detail, with bright highlights reflecting light.

The Missouri
Water
Resources Plan
is a long range,
comprehensive
strategy to:

Project Vision (MoDNR)

- ⑩ Provide an understanding of water resource needs
- ⑩ Ensure the quantity of water resources meets future water demands
 - ⑩ Identify future water supply shortfalls
 - ⑩ Explore options to address water needs

Missouri Water Resources Plan Update: Goals

- 1 Gather public and stakeholder input to help identify needs and priority areas of water resource development.
- 2 Establish key stakeholder advisory and technical groups to help guide water plan development.
- 3 Develop an updated evaluation of current groundwater and surface water availability and develop projected water supply needs.
- 4 Produce an in-depth analysis of current and future consumptive, non-consumptive and agricultural water needs, and identify gaps in water availability based on water demand projections.
- 5 Identify water and wastewater infrastructure needs, and evaluate funding and financing opportunities.
- 6 Recognize water quality and assess how this affects water supply uses.
- 7 Understand areas where developing new and more sustainable water sources, better infrastructure, and more integrated water supplies can help to sustain water delivery.
- 8 To better understand regionally where future water gaps may exist, as studies have revealed in parts of southwest and northern Missouri.

Water Demands

ALL WATER DEMAND SECTORS

Consumptive Demand Quantified



- Major water systems
- Self-supplied nonresidential
- Self-supplied domestic and minor systems
- Thermoelectric power generation (small portion consumed)
- Livestock
- Agriculture irrigation

Non-Consumptive Demand Characterized



- Hydroelectric power generation
- Commercial navigation
- Aquaculture and wetlands
- Water-based outdoor recreation
- Thermoelectric power generation (small portion consumed)

Consumptive demand refers to water that is withdrawn from the source and consumed in a way that makes its use all or partially unavailable for other purposes or uses.

Non-consumptive demand refers to uses that rely on water in the streams, rivers and lakes for everyday activities. The water is not consumed and is available for other uses.

Consumptive Demand Approach



Data Availability Review

Identify Driver and Per Unit Use

Quantify Current Water Use and Supply

Project Changes in Per Unit Use and Drivers


Forecast Water Use to 2060

Estimating Water Use at Homes and Businesses

Water Use Sectors

Major Water Systems
Self-Supplied Nonresidential
Self-Supplied Domestic and Minor Systems

Primary Data Sources



**Woods &
Poole
Demographic
Projections**

**Major Water
Users
Database**

**Census of
Public Water
Systems**

Primary Data Sources – Current Water Use

- Major Water Users Database (MoDNR)
 - Water users able to pump or divert 100,000 (or more) gallons per day required to register and report (no penalties for non-reporting)
 - Key data include source (groundwater or surface water), withdrawal points, use category, primary county, population served, annual use
- Census of Missouri Public Water Systems (2016 stats)
 - “Public Water System” = serves at least 15 connections and operated year-round or directly serves at least 25 residents (e.g., cities, water districts, subdivisions, mobile home parks, institutions)
 - **Community Systems = 1,426**
 - Includes list of sellers and buyers, general source of water, population served, average daily consumption, surface water source



Data Sources – Demographic Projections

- Projections obtained from Woods & Poole, an independent corporation specializing in long-term county projections
- Projections are cohesive and regionally based
- Includes both employment and population
- Projects employment by basic sectors where output is not consumed locally (i.e., mining, agriculture) and non-basic sectors (retail trade, construction) that depend largely on the growth of the basic sectors with some exceptions for Missouri (e.g., Information and Finance in Kansas City)
- Other options explored, State Demographer provided input on best available source



Population at County Level Quality Control

- Major Water Systems population is first calculated
- Self-Supplied Domestic and Minor Systems is the remainder
- Source: Woods & Poole

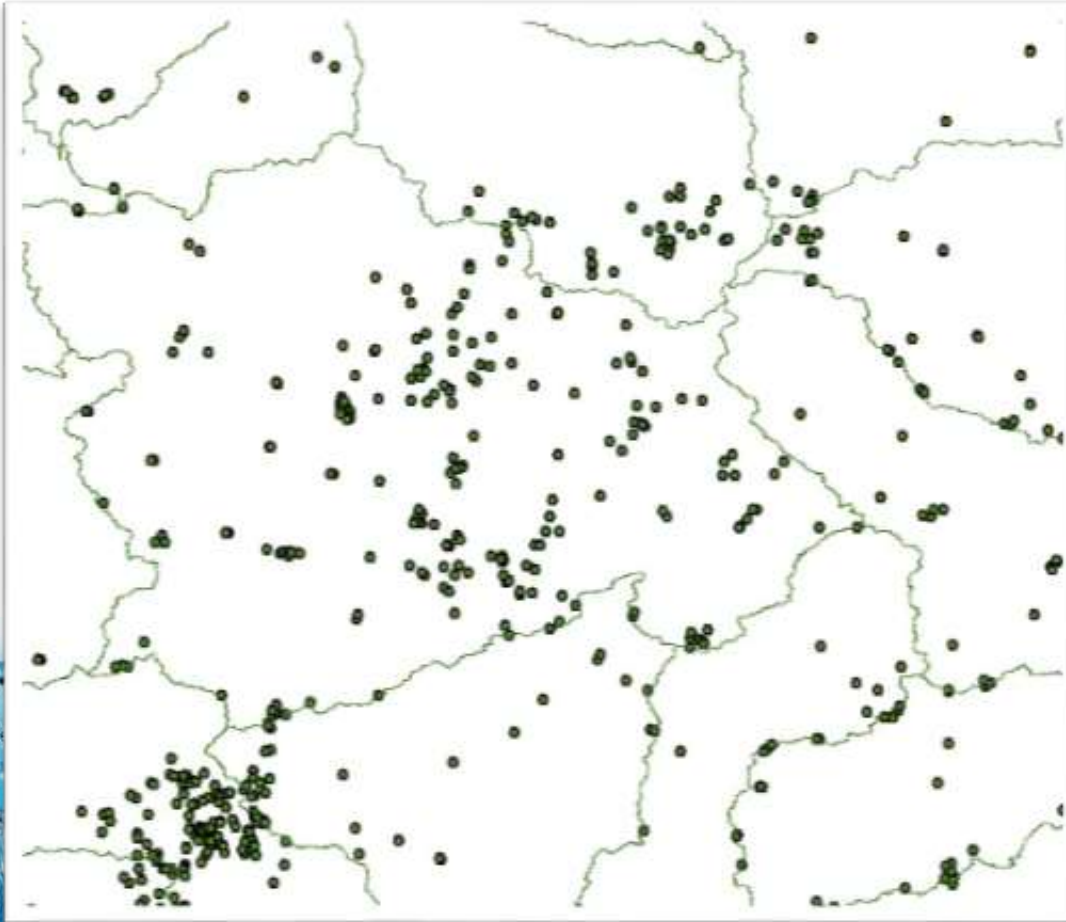
Total County Population
minus Major Water Systems
equals Self-Supplied Domestic and Minor Systems

Self-Supplied Domestic
and Minor Systems
17%



Major Water Systems
83%

Identifying Water Source



- Need source by **aquifer** (groundwater) and **HUC 8** (surface water)
- Surface water source identified from Public Drinking Water Census
- Groundwater aquifer identified from MoDNR Public Wells GIS layer



Consumptive Demand Sectors Draft Preliminary Results

Major Water Systems
Self-Supplied Domestic and
Minor Systems
Self-Supplied Nonresidential
Thermoelectric Power Generation

Major Water Systems

- **Definition**— Water that is provided by a municipal or public water supply entity to homes, businesses, and light industries
- Accounts for wholesale transfers and out of state supplies
- **Methodology**

Population Supplied



times

X

Per Capita Use Rate



Equation applied for all planning periods

2016

2020



2030

2040

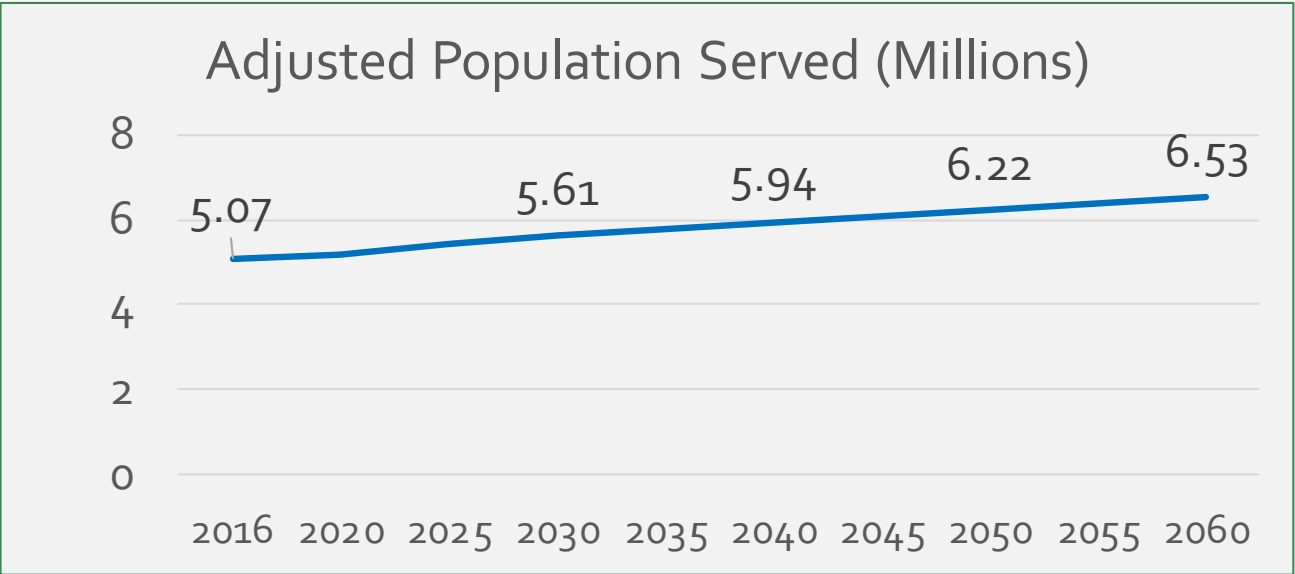
2050

2060

Major Water Systems – Population Supplied

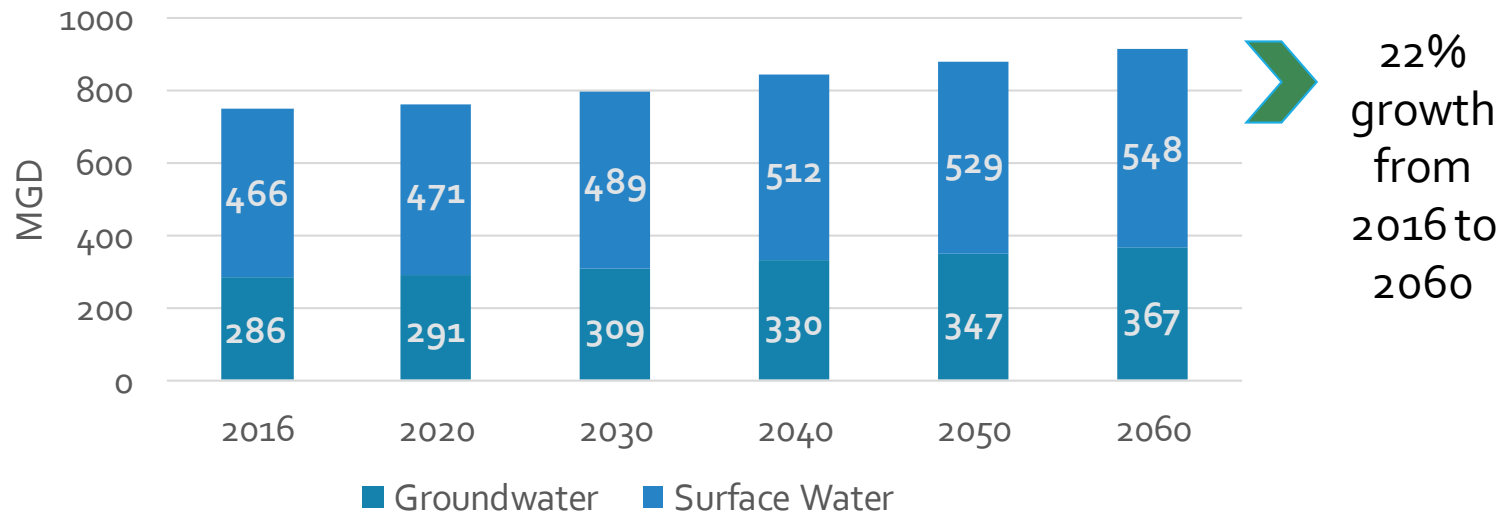
Statewide Weighted GPCD			
			
Year	2016	2030	2060
GPCD	148	144	148

Adjusted for passive conservation (to 2030)



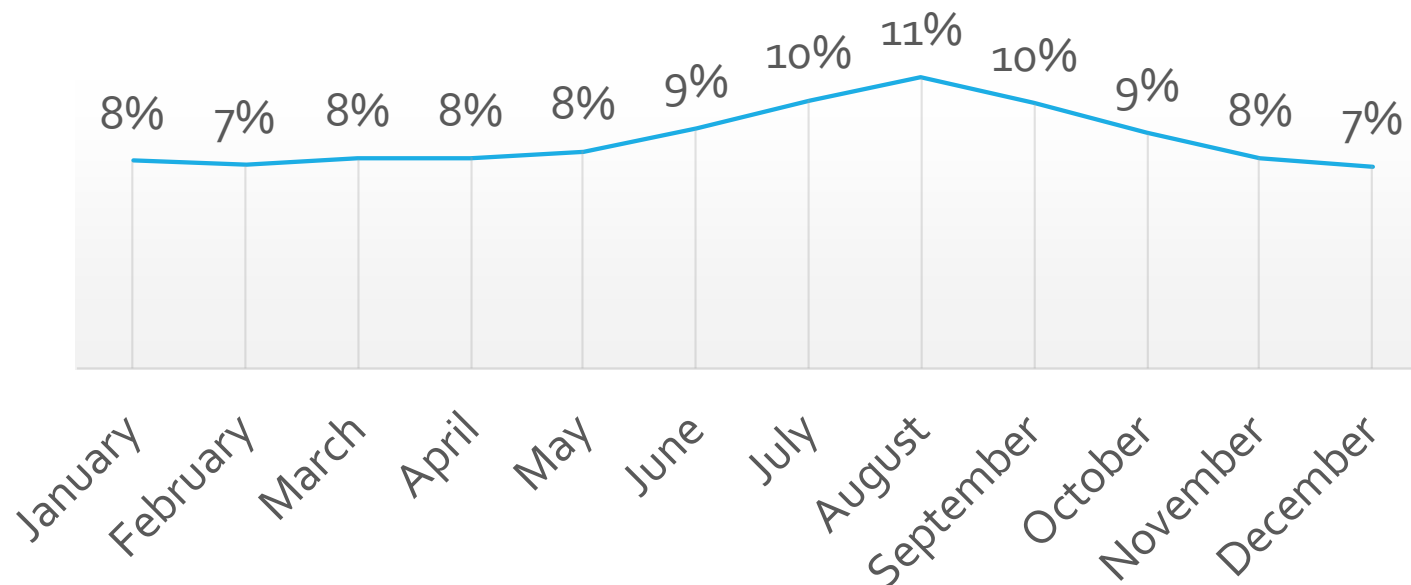
Adjusted to capture daytime population increases/decreases

Major Water Systems Water Demand (MGD)



- Ozark region has highest growth
- Top 10 highest growth counties: Boone (69%), Camden (82%), Cass (69%), Christian (123%), Clay (72%), Gasconade (59%), Platte (96%), St. Charles (73%), Taney (64%), Wayne (62%)
- Some counties have little growth or negative growth
- Groundwater demand growth of 29%
- Surface water demand growth of 18%

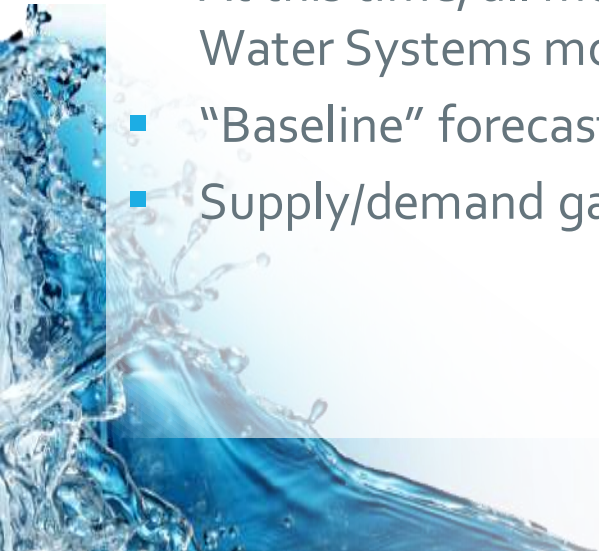
Major Water Systems - Seasonality



- Seasonality applied for calculating monthly withdrawals given annual MGD forecast data
- Applied during supply/demand analysis to determine seasonal gaps in water supply
- Data collected from publicly-available reports and studies

Major Water Systems Regional Project Incorporation

- **North Central Missouri Study**
 - 2016 Reliability Study provided data on wholesale purchasing
 - East Locust Creek Reservoir
 - Little Otter Creek
- **Northwest Missouri Regional Water Supply Transmission**
- **Southwest Missouri Water Supply Study**
- At this time, all municipalities potentially impacted are in the Major Water Systems model, regardless of size
- “Baseline” forecast will assume current source of water
- Supply/demand gap assessment will take regional projects into account



Self-Supplied Domestic and Minor Systems

- **Definition** – Water that is used by homes, subdivisions or mobile home parks that is supplied by a privately owned and operated well or a smaller public water system assumed to be using groundwater
- **Methodology**

Population Supplied



times

X

Per Capita Use Rate



Equation applied for all planning periods

2016

2020

2030

2040

2050

2060




Self-Supplied Domestic and Minor Systems

Statewide Population Served by Self-Supplied Domestic and Minor Systems - Millions

2016	2030	2060
1.05	1.14	1.30

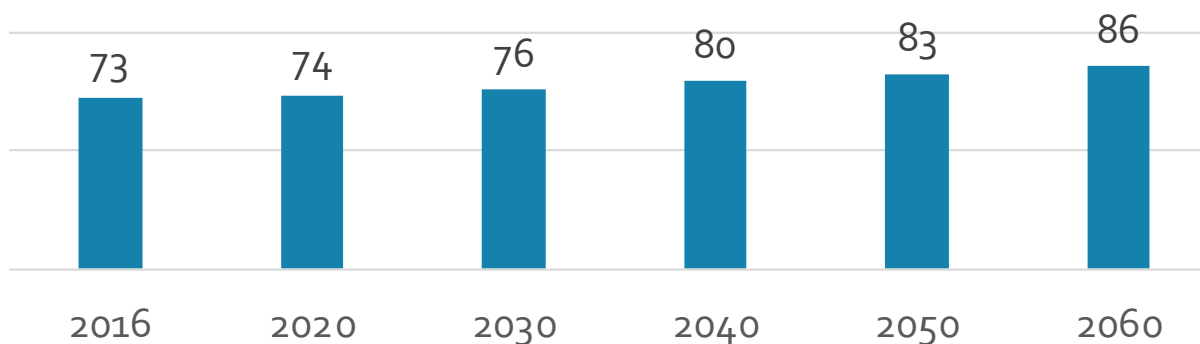
Historical USGS data assessed for trends in population on private wells and used to forecast

Statewide Weighted GPCD

			
Year	2016	2030	2060
GPCD	69	67	67

Adjusted for passive conservation

Self-Supplied Domestic and Minor Systems Water Demand Forecast (MGD)



18%
growth
from
2016 to
2060

- Ozark region has concentration and highest growth
- Central region has significant demands

	2016	2030	2060
GROUNDWATER AQUIFER	72.89	75.89	86.10
Alluvium	10.50	10.27	11.61
Ozark Aquifer (Lower)	40.96	43.25	49.68
Ozark Aquifer (Upper)	1.15	1.32	1.76
Precambrian	1.49	1.52	1.57
Springfield Plateau	0.05	0.00	0.00
St. Francois Aquifer	18.74	19.52	21.47

Self-Supplied Nonresidential

- **Definition**—Water used by nonresidential establishments, such as industries, golf courses, nursing homes, hotels, mining, and prisons that is supplied by the establishment's own source
- **Data Sources**
 - MoDNR Major Water User Database
 - Census of Missouri Public Water Systems
 - Woods & Poole 2017 Complete Economic and Demographic Data
 - MoDNR Public Wells Data
- **Methodology**

Current Nonresidential Use



times

X

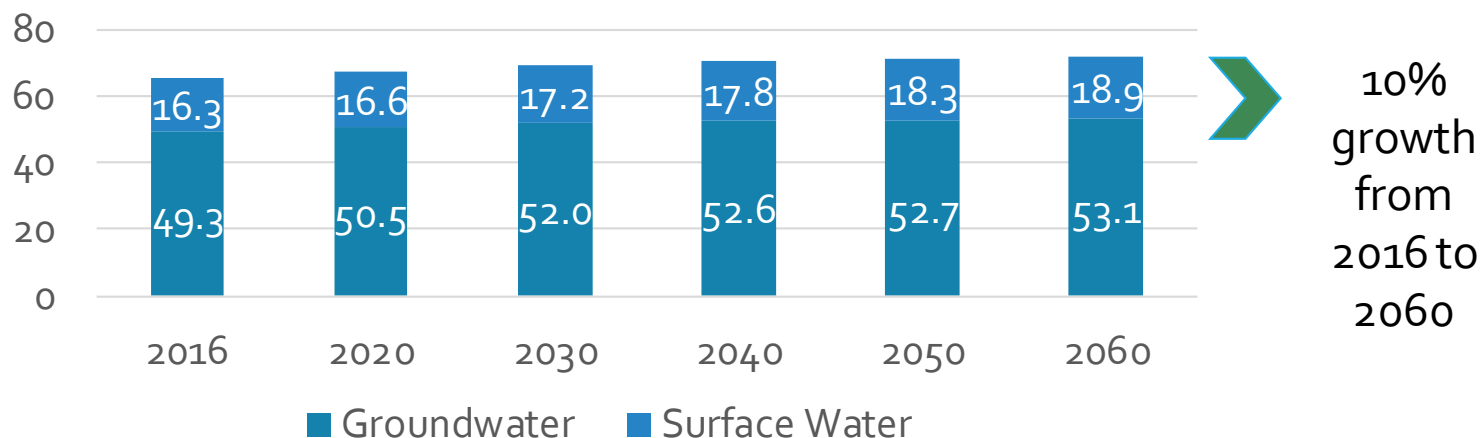
Employment Growth



Self-Supplied Nonresidential – Current Use

Category	# Users	Annual MGD
Food Manufacturing	15	25.6
Mining (except Oil and Gas)	16	18.3
Miscellaneous Manufacturing	6	3.72
Educational Services	8	3.63
Paper Manufacturing	1	2.87
Chemical Manufacturing	3	2.16
Federal Government, Excluding Post Office	4	1.64
State Government	17	1.51
Amusement, Gambling, and Recreation Industries	12	1.27
Petroleum and Coal Products Manufacturing	6	1.25
Accommodation, including Hotels and Motels	20	0.96
Computer and Electronic Product Manufacturing	2	0.80
Federal Government, Military	1	0.60
Beverage and Tobacco Product Manufacturing	1	0.50
Printing and Related Support Activities	1	0.31
Social Services	14	0.14
Other	13	0.36
STATE TOTAL	140	65.6

Self-Supplied Nonresidential Water Demand (MGD)



- Withdrawals from Upper Ozark Aquifer are forecast to increase by 68 percent; greatest amount of withdrawals from any source in 2060
- Greatest percent of growth is projected for Boone County, followed by Jefferson County and Taney County



Thermoelectric Power Generation

- **Definition** – Water required for the generation of electricity (excludes hydropower); only a small portion of the water withdrawn is consumed.
- Both non-consumptive and consumptive withdrawals are estimated
- **Data Sources**
 - U.S. Department of Energy, Energy Information Administration (923, 860, and Annual Energy Outlook)
 - U.S. Geological Survey 2010
 - Major Water Users Database
 - National Renewable Energy Laboratory – A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies
 - Ameren Missouri 2017 Integrated Resource Plan





Thermoelectric Power Generation



Major Facilities

- 24 Facilities
- 32 Generating Units
 - 7 Coal with Cooling Tower
 - 13 Coal with Once-Through Cooling
 - 11 Natural Gas with Cooling Tower
 - 1 Nuclear with Cooling Tower

Callaway Nuclear Power Plant Included

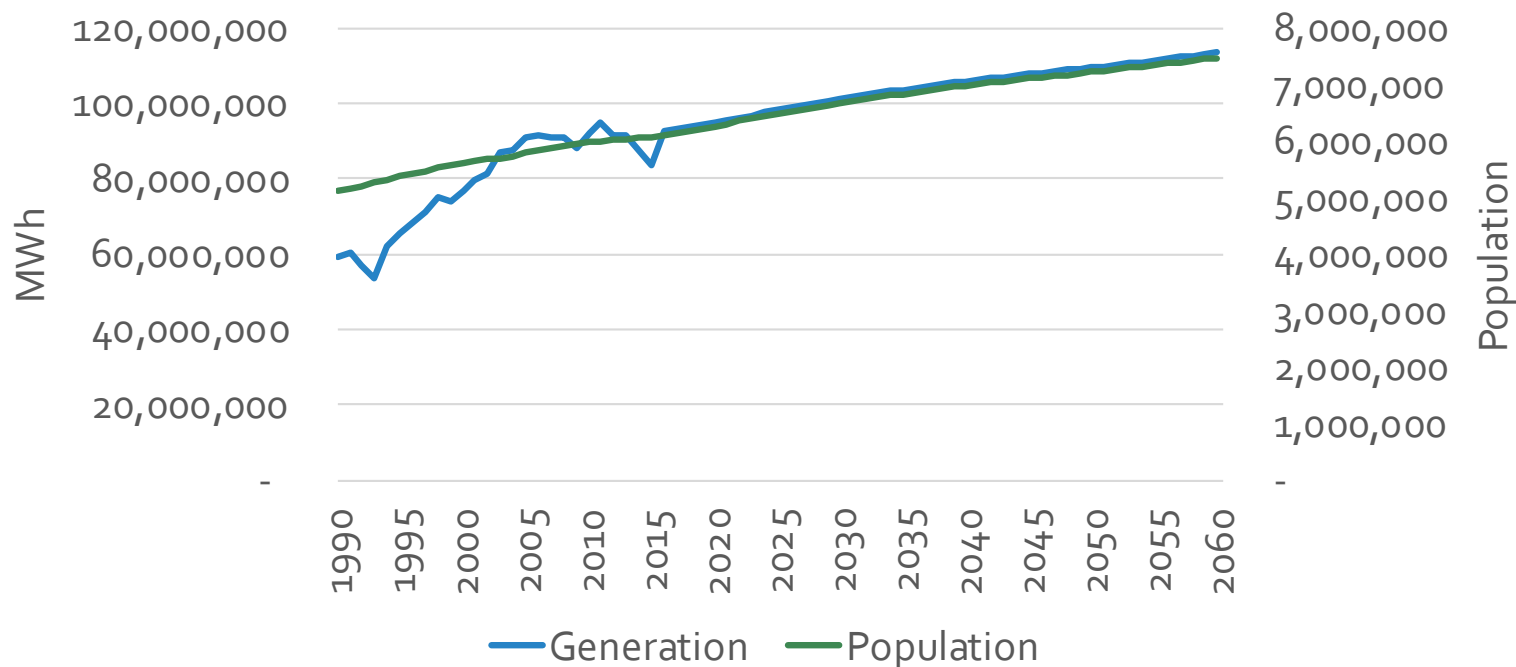
■ Features

- One facility – Callaway Energy Center
- In Callaway County
- Missouri River as source
- NRC renewed operating license in 2015 through 2044, may be extended further
- No new nuclear generating capacity planned in state

Source: Ameren Missouri 2017 IRP



Missouri Projected Population & Generation



Future generation is projected according to population growth

Growth assigned by fuel type - utilizes EIA Energy Outlook

Thermoelectric Power Generation – Consumption Rates by Configuration

Generation Configuration	Withdrawal Gallons per MWh	Consumption Gallons per MWh
Fossil/biomass, once-through cooling	36,350	250
Fossil/biomass, cooling towers	1,005	687
Nuclear, cooling towers	1,101	672
Natural gas, combined-cycle, cooling towers	253	198

Source: National Renewable Energy Laboratory – A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies

Thermoelectric Power Generation

Withdrawal Water Demand by Source in MGD

Source	2015	2020	2030	2040	2050	2060
GW	9.42	9.35	9.50	9.51	9.38	9.71
GW Alluvium	33.13	32.37	32.80	31.00	33.66	34.85
SW	6,054	5,907	5,784	4,728	5,205	5,389
Total	6,096	5,949	5,827	4,768	5,248	5,434

Consumption Water Demand by Source in MGD


Source	2015	2020	2030	2040	2050	2060
GW	6.54	6.50	6.64	6.68	6.62	6.86
GW Alluvium	2.87	2.83	2.85	2.82	2.77	2.87
SW	60.9	59.4	58.3	50.4	52.7	54.6
Total	70.3	68.8	67.8	59.9	62.1	64.3

Decline in use attributable to retirement of coal-fired facilities with once-through cooling

Agricultural Needs

Crop Irrigation

- **Definition** – Water required to supplement natural rainfall for the commercial production of crops such as corn, soybeans, wheat, specialty vegetables, and orchards
- **Methodology**
Irrigated Acres X Crop Irrigation Requirement
- Only current water demands have been estimated
- Future demands will be forecasted in the coming months



Irrigation Style	Efficiency
Sprinkler	75%
Surface (Furrow)	50%
Micro-Irrigation	90%

Irrigation Estimation Data Sources

Data Type	Data Source
Crop acreage	2012 USDA Census of Agriculture
County rankings by crop	2012 USDA Census of Agriculture
Crop planting/harvest estimates	Missouri Crop Resource Guide
Crop evapotranspiration coefficients	FAO
Missouri crop regions	Missouri Crop Resource Guide
County-level temperature data	High Plains Regional Climate Center
County-level precipitation data	High Plains Regional Climate Center



Irrigation – Current Crop Water Demands (Billion Gallons per Year)

DRAFT RESULTS

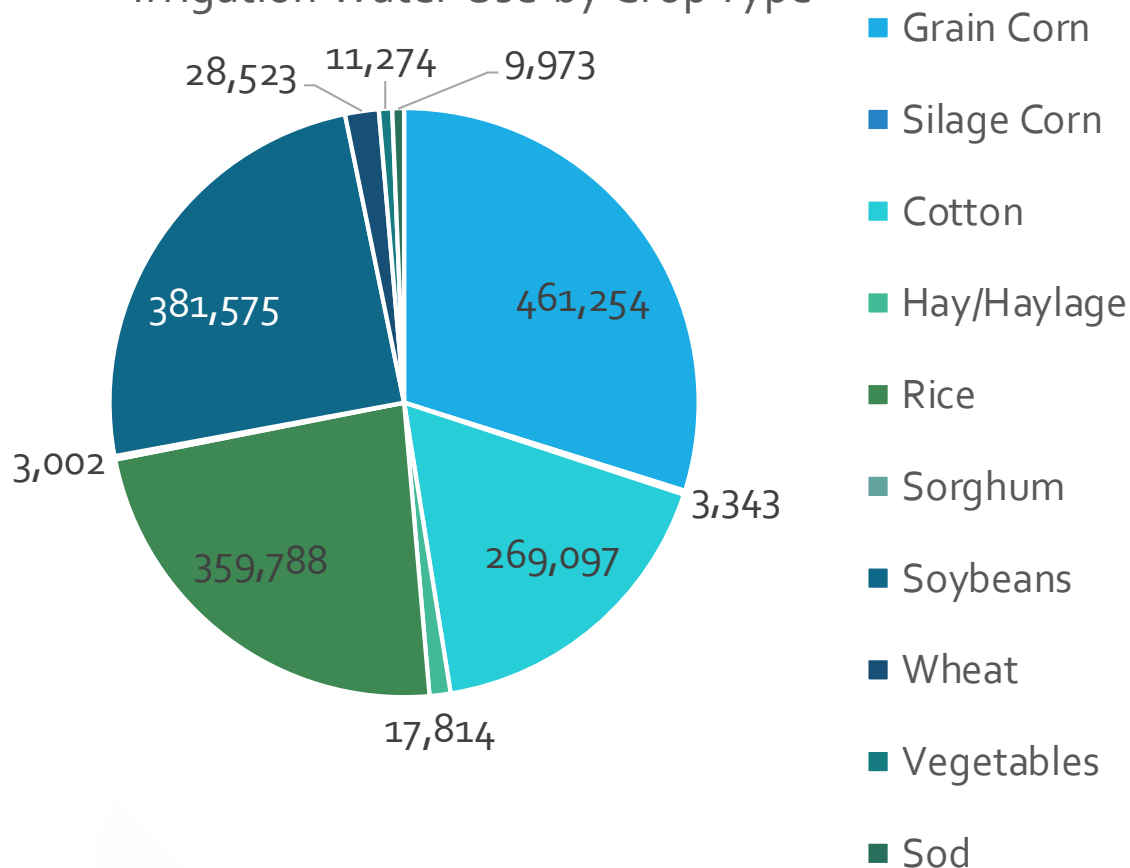
Total Demand

503.6 BGY

1,380 MGD

1,545,492 AFY

Irrigation Water Use by Crop Type



*Irrigation and livestock demands represent current use and are not yet forecasted

Livestock

- **Definition** – Water required for the production of animals to meet dietary, sanitation, and overall animal health
- **Methodology**

Number of Animals X Animal Water Requirement

- Only current water demands have been estimated
- Future demands will be forecasted in the coming months



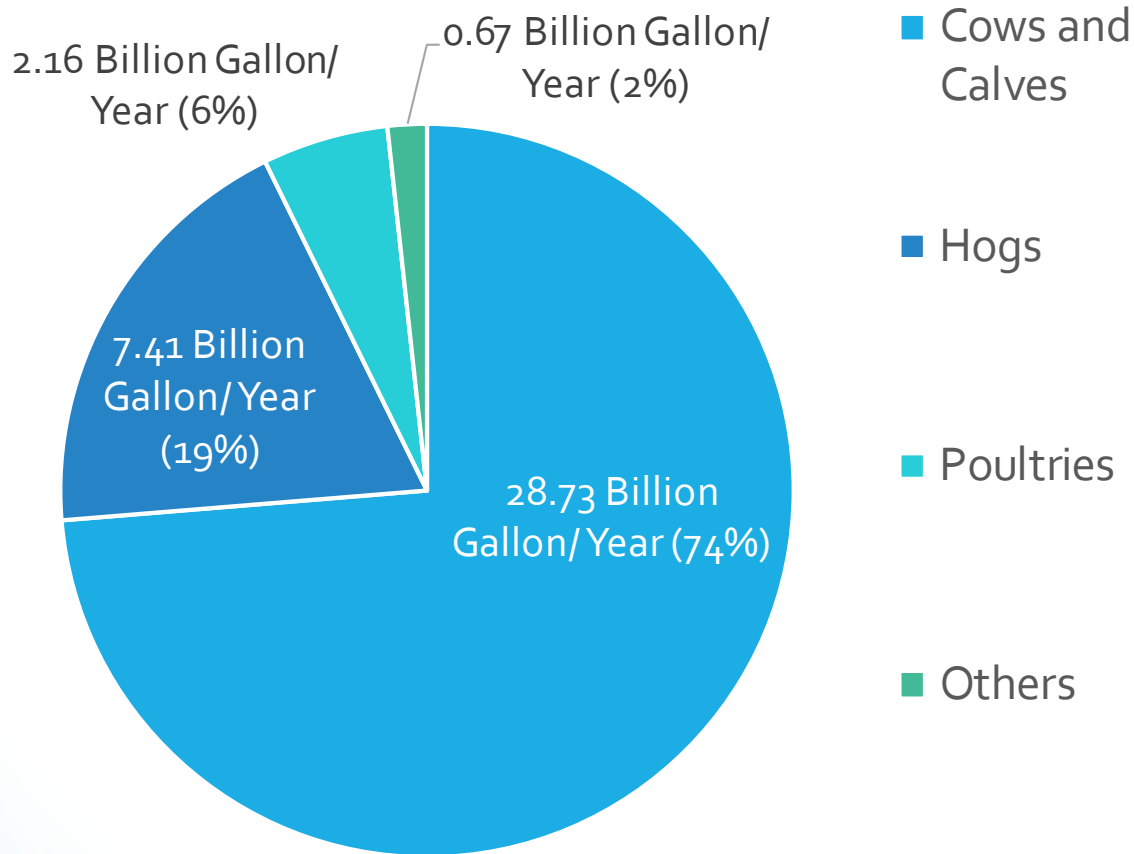
Livestock

	Animal Count	Gallon per Head per day	Total Demand (MGD)
Cows and Calves	3,703,120	18	66.7
Beef Cows	1,683,731	22.75	38.3
Dairy Cattle	92,952	30	2.79
Other Cattle	1,926,437	18	34.7
Cattle/Calves Sold	2,297,985	18	52.3
Swine	2,774,597	6	16.6
Swine Sold	9,727,491	6	58.4
Sheep	91,967	2	0.18
Sheep Sold	62,049	2	0.12
Goats	103,669	1.25	0.13
Goats Sold	56,087	1.25	0.07
Broilers	46,880,714	0.06	2.81
Broilers Sold	272,389,497	0.06	16.3
Layers	8,276,409	0.045	0.37
Layers Sold	3,897,402	0.045	0.18
Turkeys	7,572,505	0.092	0.70
Turkeys Sold	18,568,732	0.092	1.71
Horses	117,295	11	1.29
Horses Sold	15,169	11	0.17
TOTAL	380,237,808		294

* Irrigation and livestock demands represent current use and are not yet forecasted

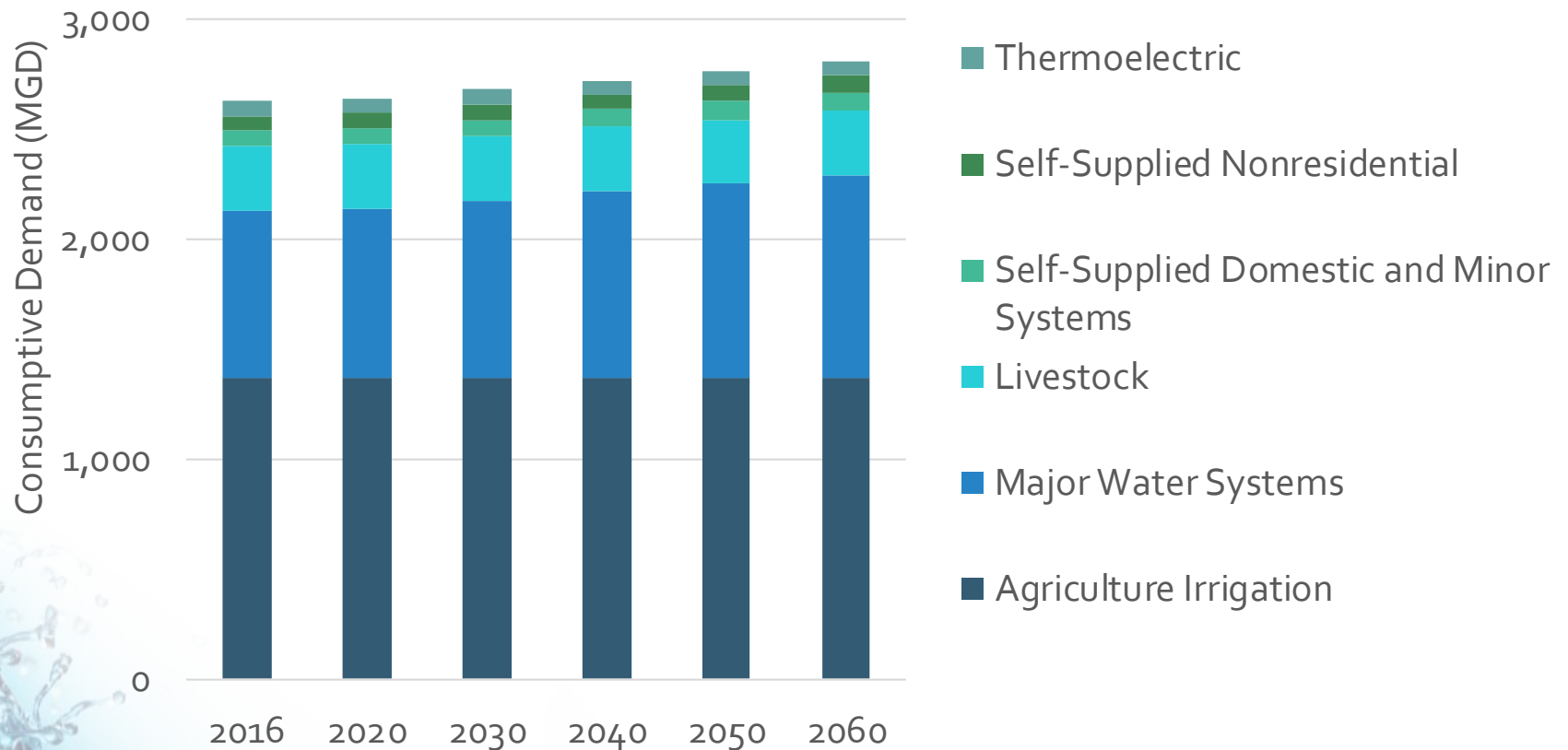
Livestock – Current Water Demands (Billion Gallons per Year)

DRAFT RESULTS



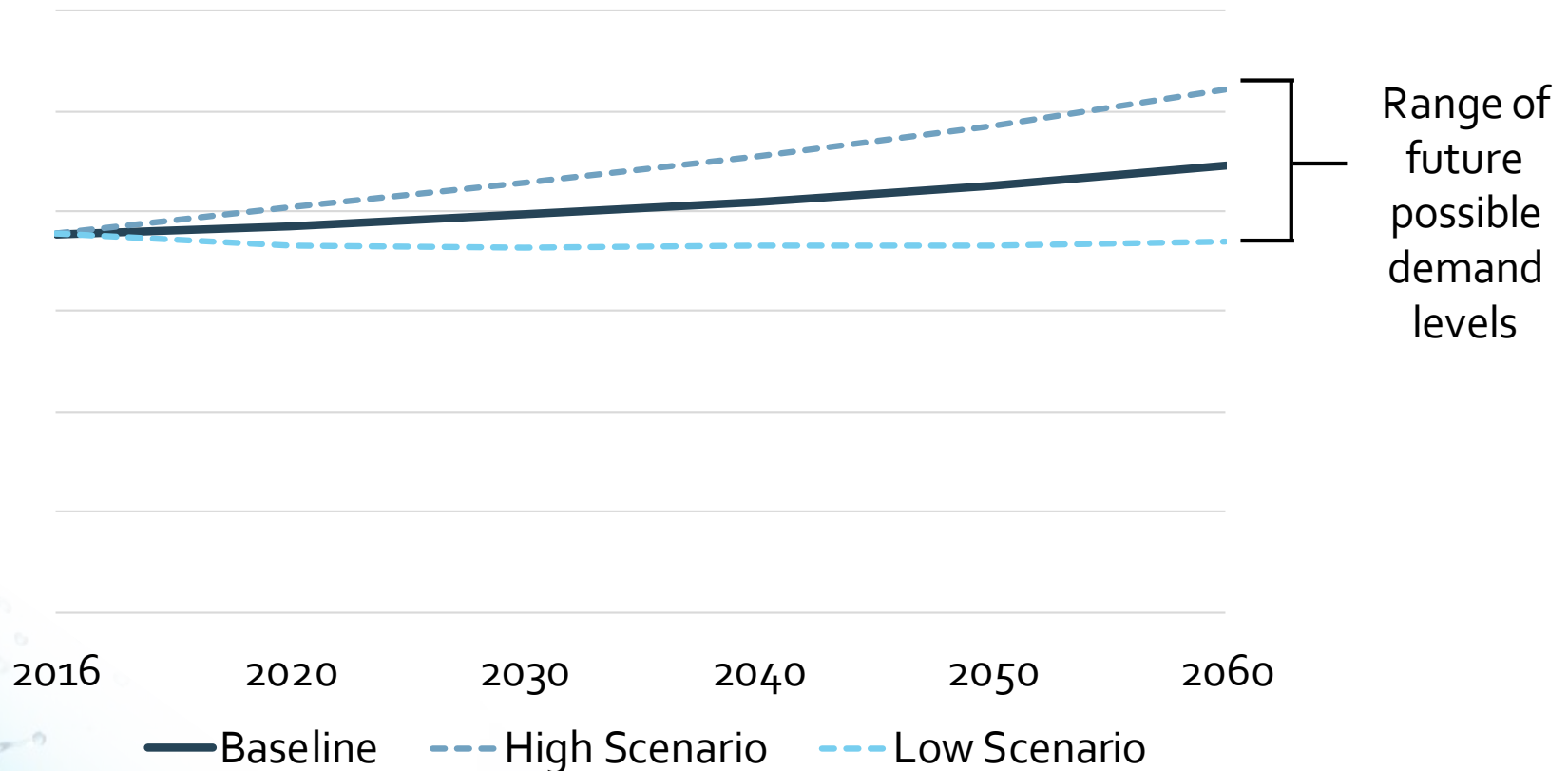
Consumptive Demands – ALL SECTORS

Statewide Consumptive Demand Forecast (MGD)



* Irrigation and livestock demands represent current use and are not yet forecasted

Consumption Demand Forecast Capturing Uncertainty



Scenarios will be developed in coming months

Non-Consumptive Needs

Non-Consumptive Demands

Definition

Sectors that rely on water in the streams, rivers, and lakes for everyday activities.

The water is not consumed and is available for other uses.


Goal

Identify and characterize the major non-consumptive sectors that rely on water.



Non-Consumptive Demand

Overview of Approach



Include in
Missouri Water
Resources Plan
(where applicable)

How water is used

What activities does water support

Importance of sector to the state

Quantify water needs

Map locations of key use and
infrastructure

Future outlook

Identify data gaps and needs

Non-Consumptive Demand

Sample of Results

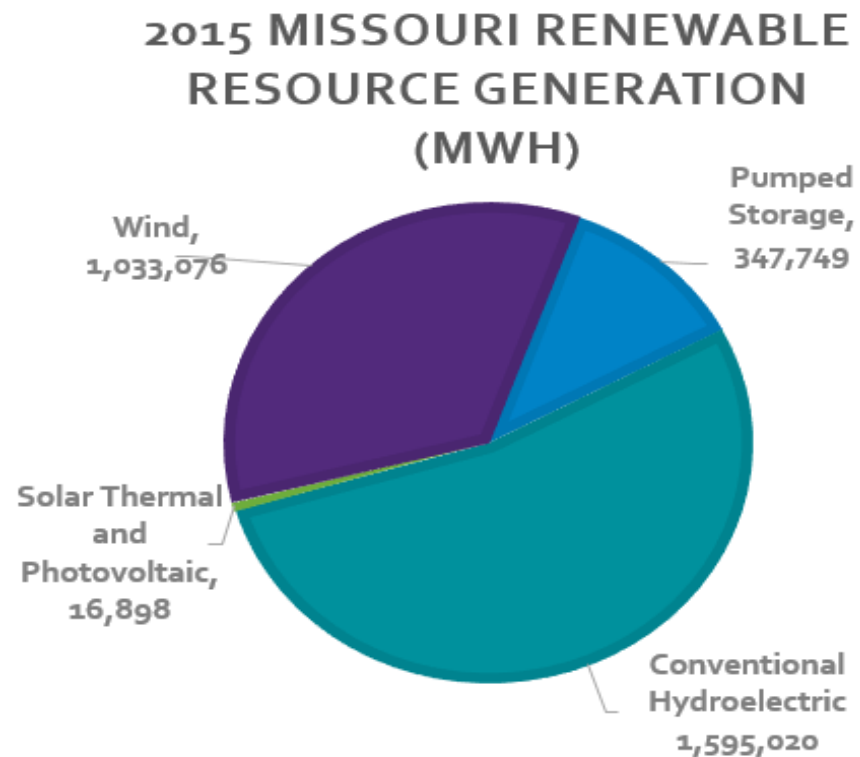




Non-Consumptive Demand

Hydroelectric Power Generation

- **Definition** – Water for generating hydroelectric power through riverine dams or other structures.
- **Features**
 - Identify and describe major facilities
 - Quantify net generation
 - Characterize reservoir water requirements
 - Economic benefits
 - Future Outlook, potential resources



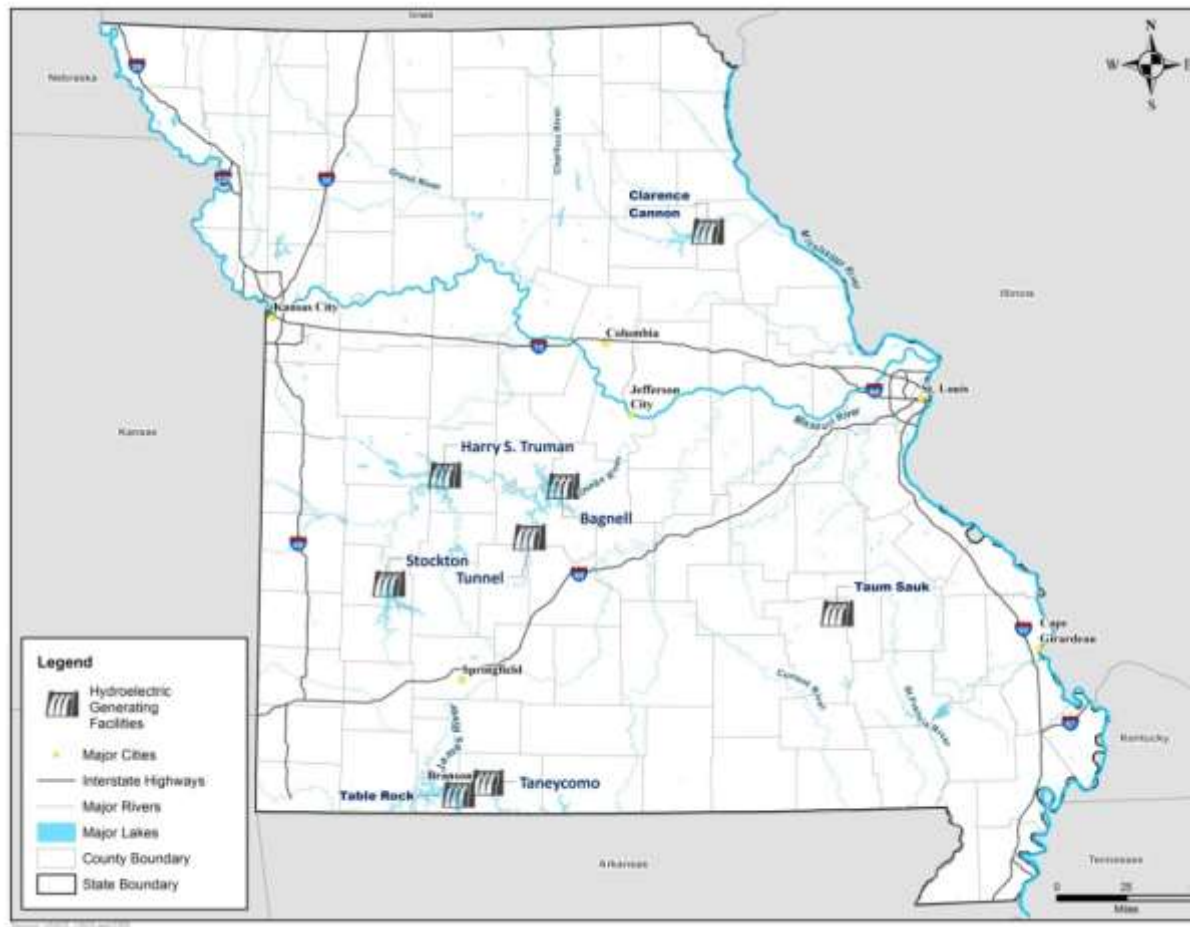
Source: U.S. Energy Information Administration - Net Generation by State by Type of Producer by Energy Source



Non-Consumptive Demand

Hydroelectric Power Generation

Major Hydroelectric Facilities





Non-Consumptive Demand

Hydroelectric Power Generation

Major Hydroelectric Plant Facility Overview

Plant Name	Facility Type	2014 Net Generation (MWh)	Owner/Operator
Clarence Cannon	Impoundment and Pumped Storage	84,772	USACE
Harry S. Truman	Pumped Storage	98,877	USACE
Niangua	Diversion	686	Sho-Me Power Electric Coop
Osage Dam (also know as Bagnell)	Impoundment	232,190	Union Electric Company
Powersite (Lake Taneycomo)	Diversion	60,693	Empire District Electric Co
Stockton Hydro	Impoundment	5,958	USACE
Table Rock	Impoundment	368,917	USACE
Taum Sauk	Pumped Storage	-135,904	Union Electric Company

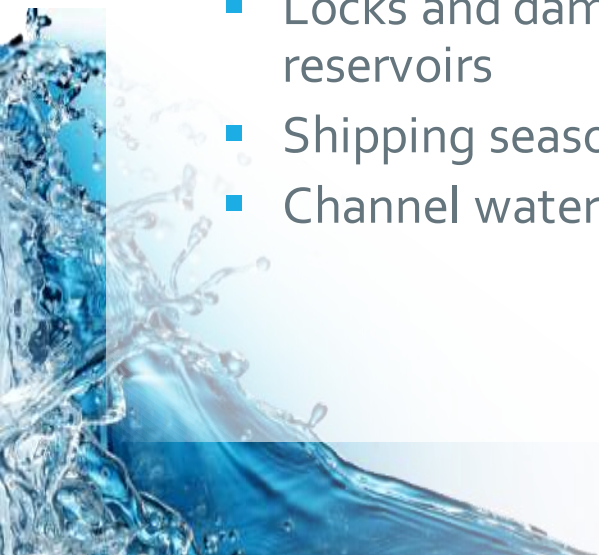
Source: U.S. Department of Energy, Energy Information Administration
Power Plant Operations Report, 2015



Non-Consumptive Demand

Commercial Navigation

- **Definition** – Water for transporting barges and boats that carry grain, raw materials, and other bulk freight.
- **Features**
 - Identify commercially navigable rivers
 - Efficiency benefits
 - Economic benefits
 - Tonnage shipped by river segment
 - Identify key infrastructure
 - Locks and dams, port authorities and toll ferries, water control reservoirs
 - Shipping season
 - Channel water depth requirement

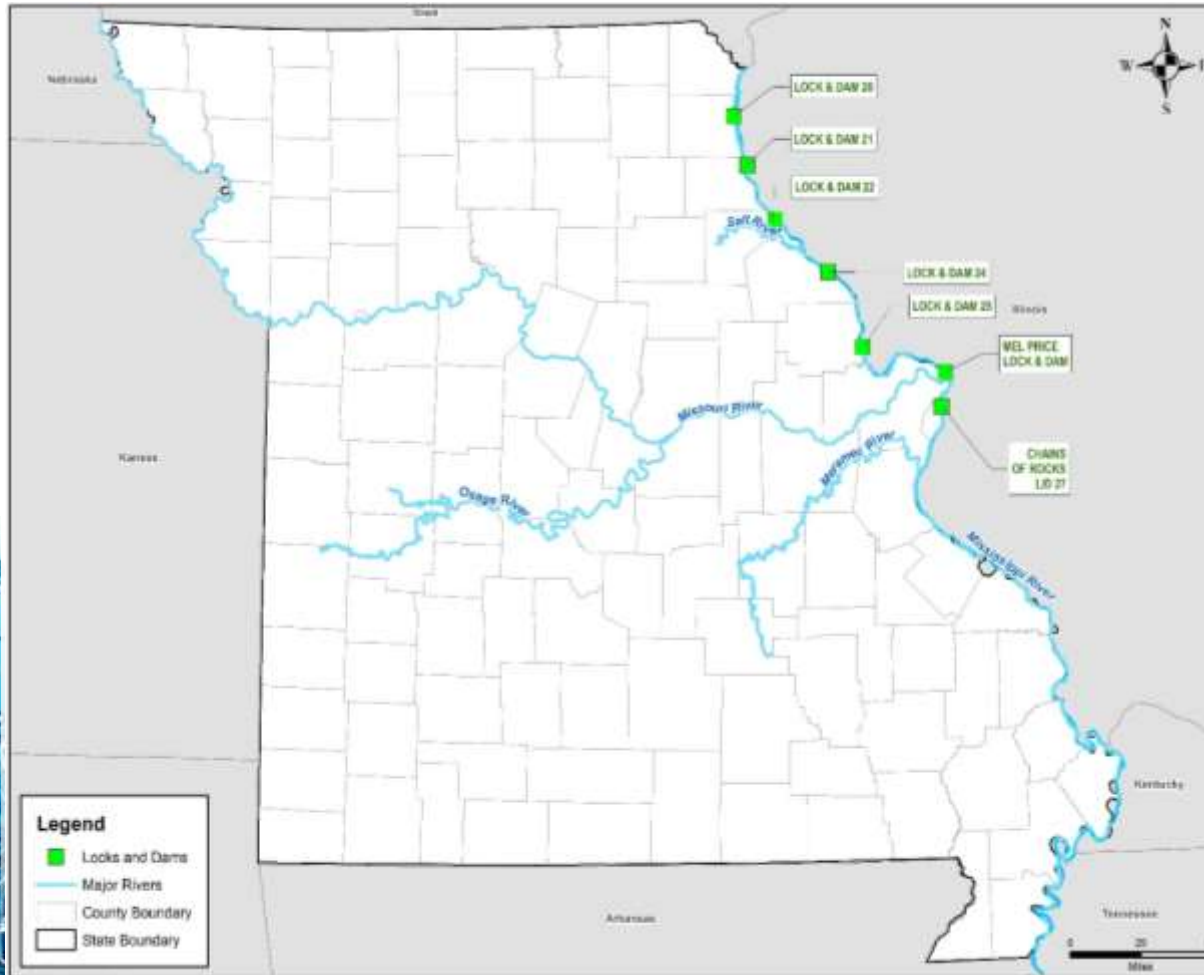




Non-Consumptive Demand

Commercial Navigation

Mississippi River Water Requirements



- 9 ft navigation channel maintained by a series of locks and dams
- Regular dredging and river training structures such as weirs aid in maintaining navigation channel



Non-Consumptive Demand

Commercial Navigation

Missouri River Water Requirements

- Water is released from six mainstream flood control reservoirs to maintain a channel 300 feet wide and 9 feet deep
- Flow of approximately 41,000 cfs at Kansas City provides full service navigation
- Flow of approximately 35,000 cfs at Kansas City provides minimum support to navigation



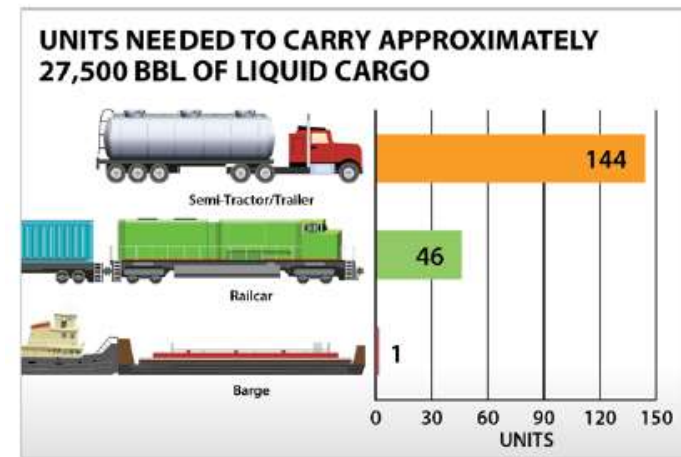
Source: USACE (2006), Missouri River Mainstem Reservoir System Master Water Control Manual



Non-Consumptive Demand

Commercial Navigation

- Efficiency benefits
 - Inland towing 36% more efficient than railroads
 - Inland towing 346% more efficient than truck freight
- Waterways are safer means of transporting goods; fatalities per million ton-miles:
 - Highway = 0.00174
 - Railroad = 0.00048
 - Water = 0.00002
- Lower greenhouse gas emissions per ton-miles



Source: Texas Transportation Institute - A Modal Comparison of Domestic Freight Transportation Effects on the General Public, 2017



Non-Consumptive Demand

Commercial Navigation

Future Outlook

- 2030 Projections
 - 63.3 million tons of waterborne freight
 - ~ \$15.5 billion value of cargo



Source: Missouri Department of Transportation, Missouri State Freight Plan



Non-Consumptive Demand

Aquaculture and Wetlands

- **Definition** – Water that supports wetland restoration and preservation as well as aquaculture.
- **Features**
 - Wetland reserve easement mapping
 - Estimate withdrawals for wetland reserve easements based on proximity to irrigation well or surface water source
 - Aquaculture withdrawals
 - Economic benefits of hunting and fishing sector



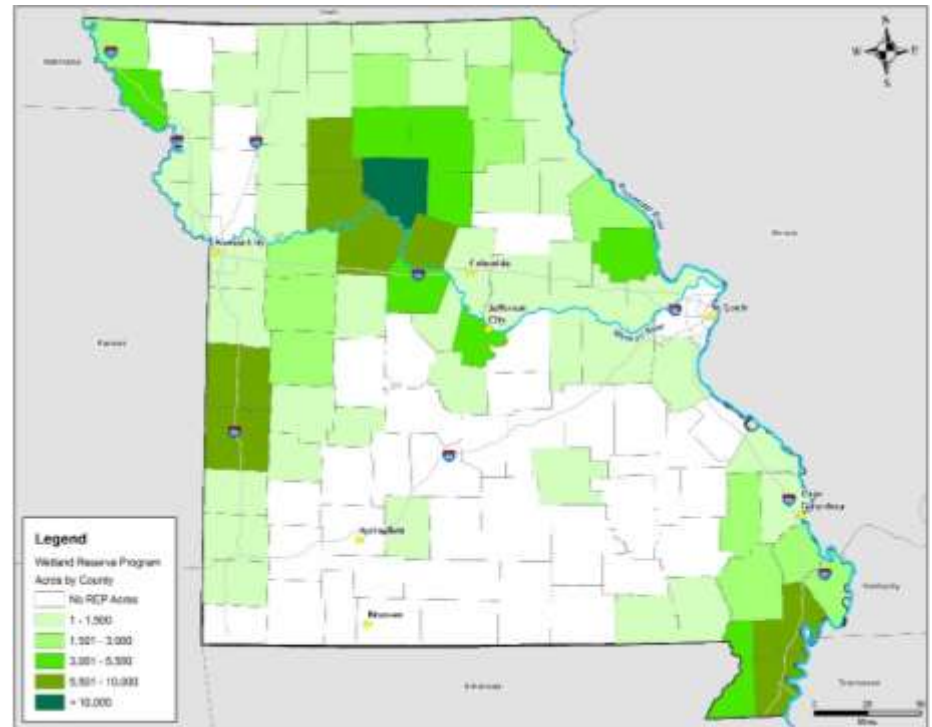


Non-Consumptive Demand

Aquaculture and Wetlands

Wetland Reserve Easement

- Approximately 145,726 acres of wetland easements enrolled in the WREP program in Missouri; 1100 easements
- Approximately \$82 million paid in wetland easements through the WREP in Missouri
- 68% of WREP acres located in proximity to a diversion or well, assuming those are flooded in fall and drained in spring to plant food
- ~73,000 acre feet per year withdrawn (18 inches of water over one-third of acres in proximity to supply)





Non-Consumptive Demand

Aquaculture and Wetlands

Wetland Withdrawals by Source

Source		Acres within Proximity of Source	Withdrawal (AF)
AQUIFER	Alluvium	26,647	13,190
	Ozark Aquifer (Lower)	19,813	9,807
	Ozark Aquifer (Upper)	4,852	2,402
	Ground Water Total	51,312	25,399
HUC 4	Chariton-Grand	14,872	7,362
	Des Moines	1,157	572
	Gasconade-Osage	2,226	1,102
	Lower Mississippi-Hatchie	5,836	2,889
	Lower Mississippi-St. Francis	2,967	1,469
	Lower Missouri	10,577	5,236
	Missouri-Nishnabotna	3,877	1,919
	Neosho-Verdigris	836	414
	Upper Mississippi-Kaskaskia-Meramec	599	296
	Upper Mississippi-Salt	4,249	2,103
	Upper White	912	451
	Surface Water Total	48,109	23,814
Total		99,421	49,213

Source identified from MoDNR's Major Water Users Database and Public Wells Data



Non-Consumptive Demand

Aquaculture and Wetlands

Aquaculture Withdrawals

- Missouri Aquaculture Directory lists 69 aquaculture related businesses
- Missouri Department of Conservation owns nine fish hatcheries
 - 4 fish hatcheries reported water use between 2013 and 2016
 - Water use averaged 14.9 to 61.9 billion gallons per year
- USGS reported aquaculture withdrawals of 180.5 MGD in 2010

Source	Aquaculture Withdrawals (MGD)	% of Source
Groundwater	10.5	6%
Surface Water	170	94%
Total	180.5	100%

Source: U.S. Geological Survey - Estimated Use of Water in the United States in 2010



Non-Consumptive Demand

Water-Based Outdoor Recreation

- **Definition** – Water that supports human recreational activities such as fishing, swimming, boating, and canoeing.
- **Features**
 - Waters suitable for recreation
 - Visitation levels
 - Water by activity – trout waters and float rivers
 - Water needs for trout production
 - Access points
 - Economic benefits

In 2012, annual visitation for all USACE reservoirs in Missouri totaled 15.9 million and were estimated to add \$170 million to the economy surrounding the lakes.





Non-Consumptive Demand

Water-Based Outdoor Recreation

- Waters Suitable for Recreation
 - Missouri Code of State Regulations designates suitable waters for whole body or secondary contact
 - **Whole body contact:** activities where a person is in contact with the raw surface water to the point of submergence (e.g., Swimming, Water Skiing, Diving)
 - **Secondary contact:** activities that require limited, incidental contact with the surface water (e.g., Fishing, Wading, Boating)

Source	Designated Secondary Contact Recreation – Public	Designated Whole Body Contact – Public	Designated Whole Body Contact – Open to the Public
Rivers/Streams (miles)	109,496	108,861	6,282
Lakes (acres)	318,939	318,939	260,950

Source: Missouri Spatial Data Information Service



Non-Consumptive Demand

Water-Based Outdoor Recreation

Trout Waters

- Trout habitat is limited to 377 miles of permanent streams that are designated as suitable for “coldwater sport fishery”
- 145 miles of streams are actively managed for trout fishing by MDC
- 4 trout parks
- 7 trout management areas
- 8 wild trout management areas
- 28 urban winter trout areas in St. Louis and Kansas City Lakes
- Trout program relies on water supplies and can be impacted by low flows in the spring

Facility	Water Supply Available (cfs)	Water Supply Needed (cfs)
Bennett Spring	150	31
Maramec Spring	144	11
Montauk	82	31
Roaring River	32	19
Shepherd of the Hills	22	22

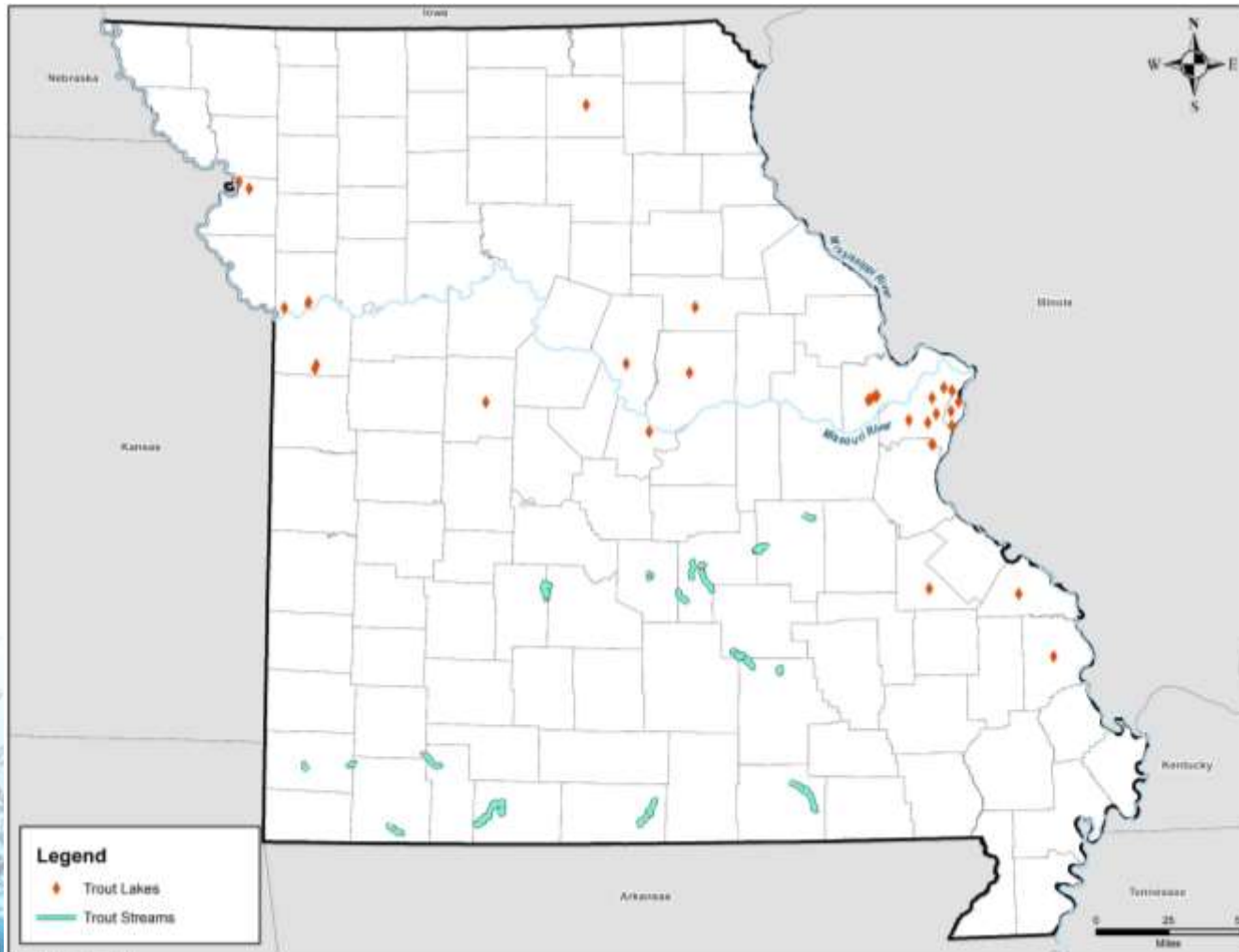
Source: MDC 2003



Non-Consumptive Demand

Water-Based Outdoor Recreation

Trout
Lakes and
Streams



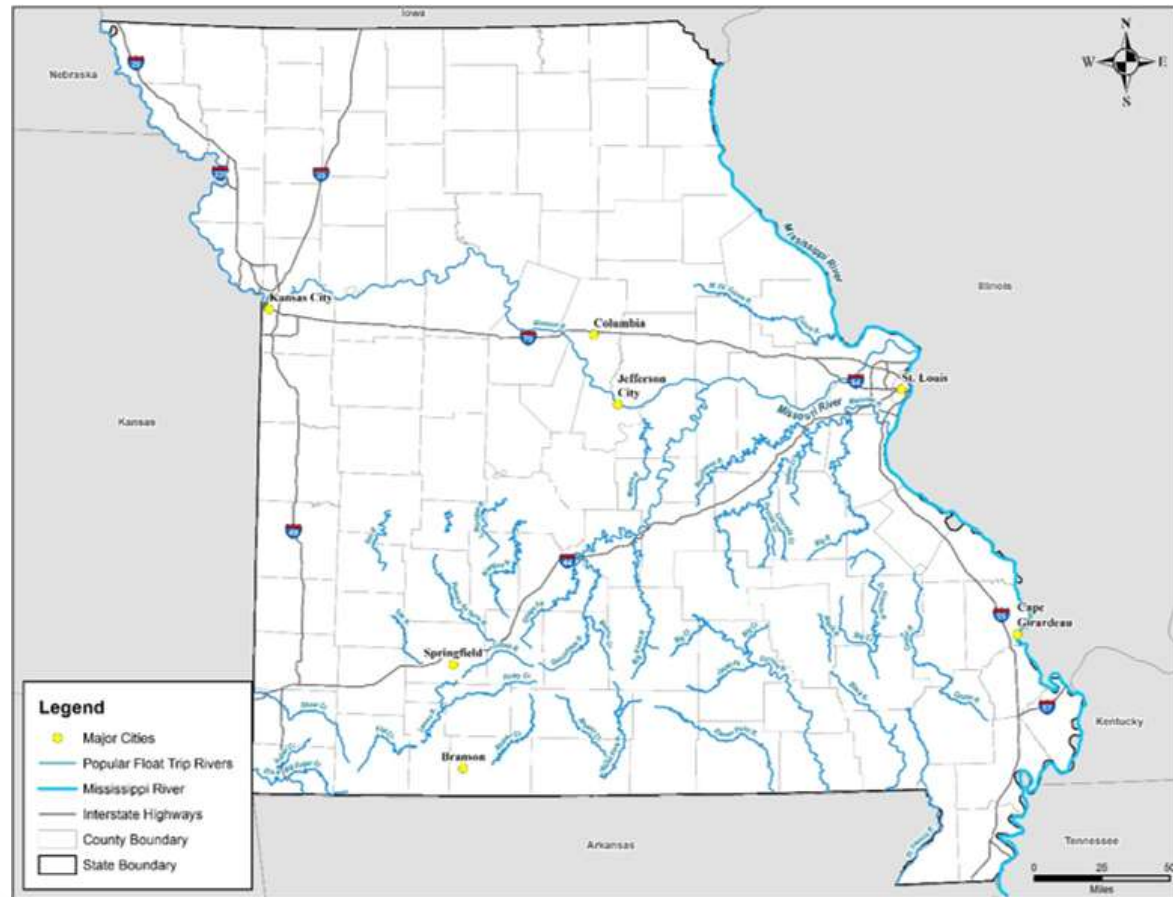


Non-Consumptive Demand

Water-Based Outdoor Recreation

Float Rivers

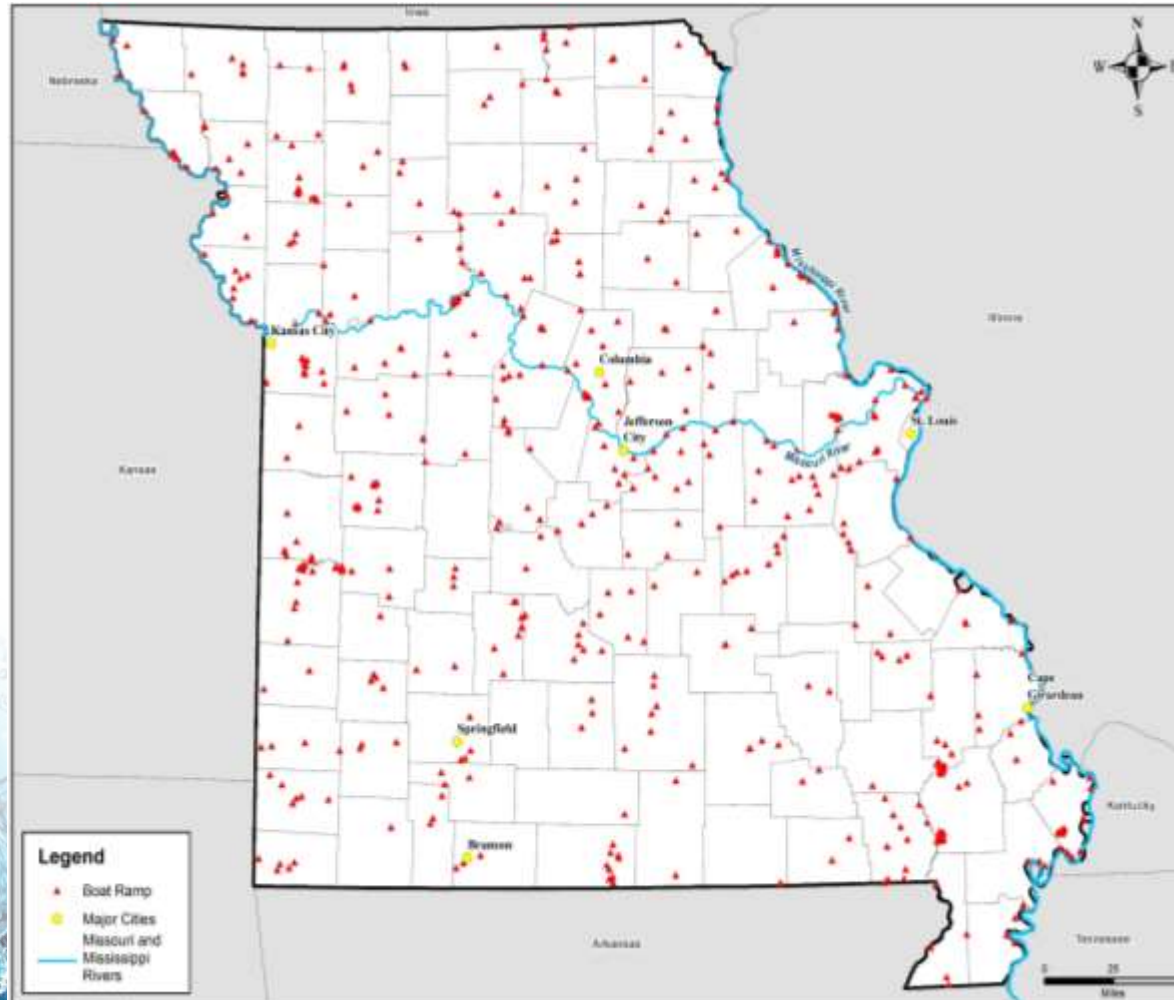
- Floating
- Canoeing
- Kayaking





Non-Consumptive Demand

Water-Based Outdoor Recreation



Water Access Points

- Missouri Department of Conservation manages 586 water access points
- 293,660 registered boats in Missouri (2015)



Non-Consumptive Demand

Water-Based Outdoor Recreation

Economic Impacts

- \$14.9 billion in spending annually on outdoor recreational
- \$889 million in state and local taxes
- Outdoor recreation supports ~133,000 jobs in Missouri
 - \$4.6 billion in wages and salaries per year
- \$685 million spent on fishing activities in 2011 which contributed to:
 - Nearly 11,000 jobs
 - \$211 million in federal taxes
 - \$181 million in local and state taxes
 - \$13.08 million on fishing licenses

Source: Congressional Sportsmen's Foundation Sportsmen's Economic Impact Report

Surface Water Supply Short Version



Surface Water Supply Task Discussion – Discussion Objectives

- Water supply analysis goals
- Overview of water budget
- Future outcomes and schedule



Surface Water Supply Analysis Goals

- At a HUC 4 level, evaluate and summarize:
 - Surface water availability (streamflow)
 - Demands, both consumptive and non-consumptive
 - Gaps in available supply compared to demands
- Representative wet, dry, and average years will be evaluated on an annual and monthly basis



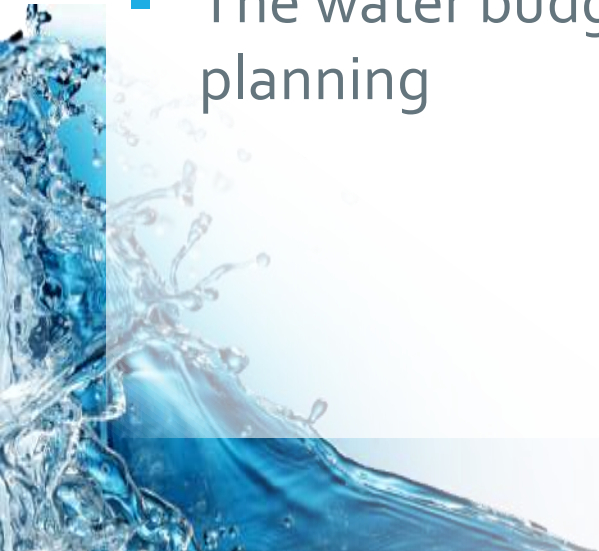
Surface Water Supply Analysis Goals (continued)

- Both supply and demands will be projected to 2060
 - Supply will be projected using hydrologic variability scenarios
 - Demands have been projected based on population growth
- Results will support the infrastructure task

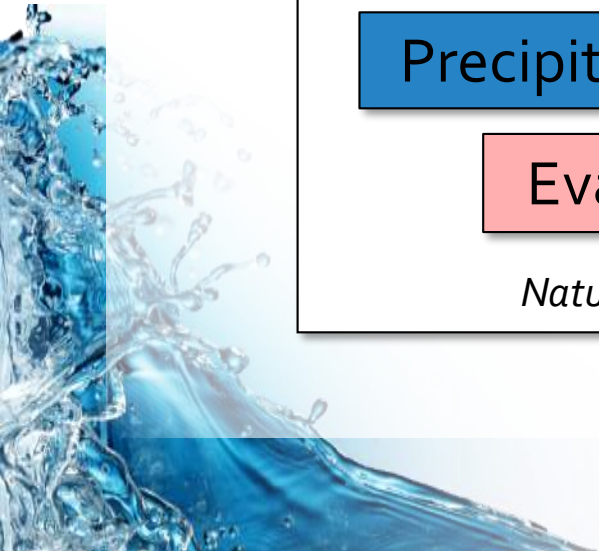
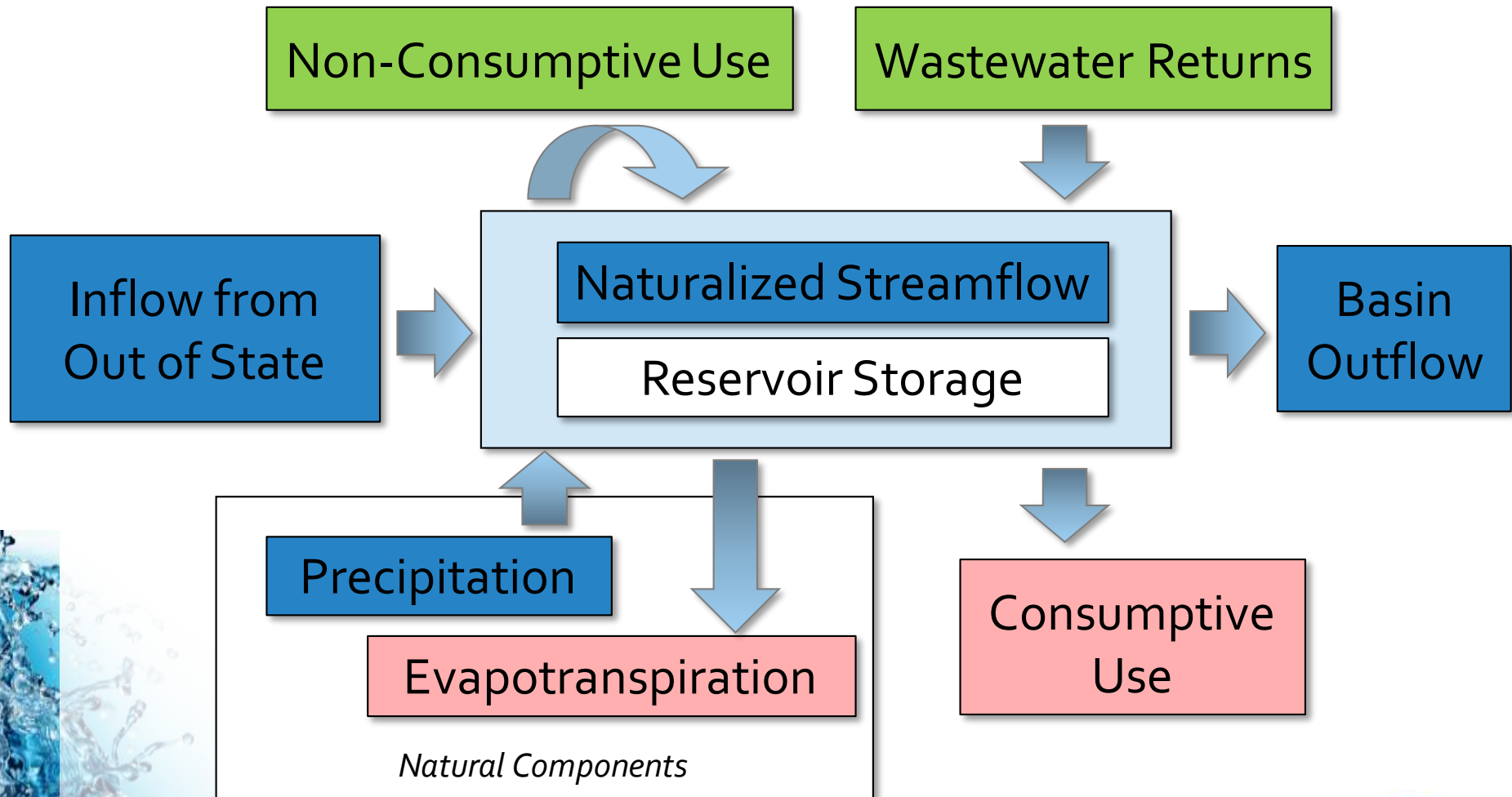


How Water Budgets Will Support Missouri's Water Plan

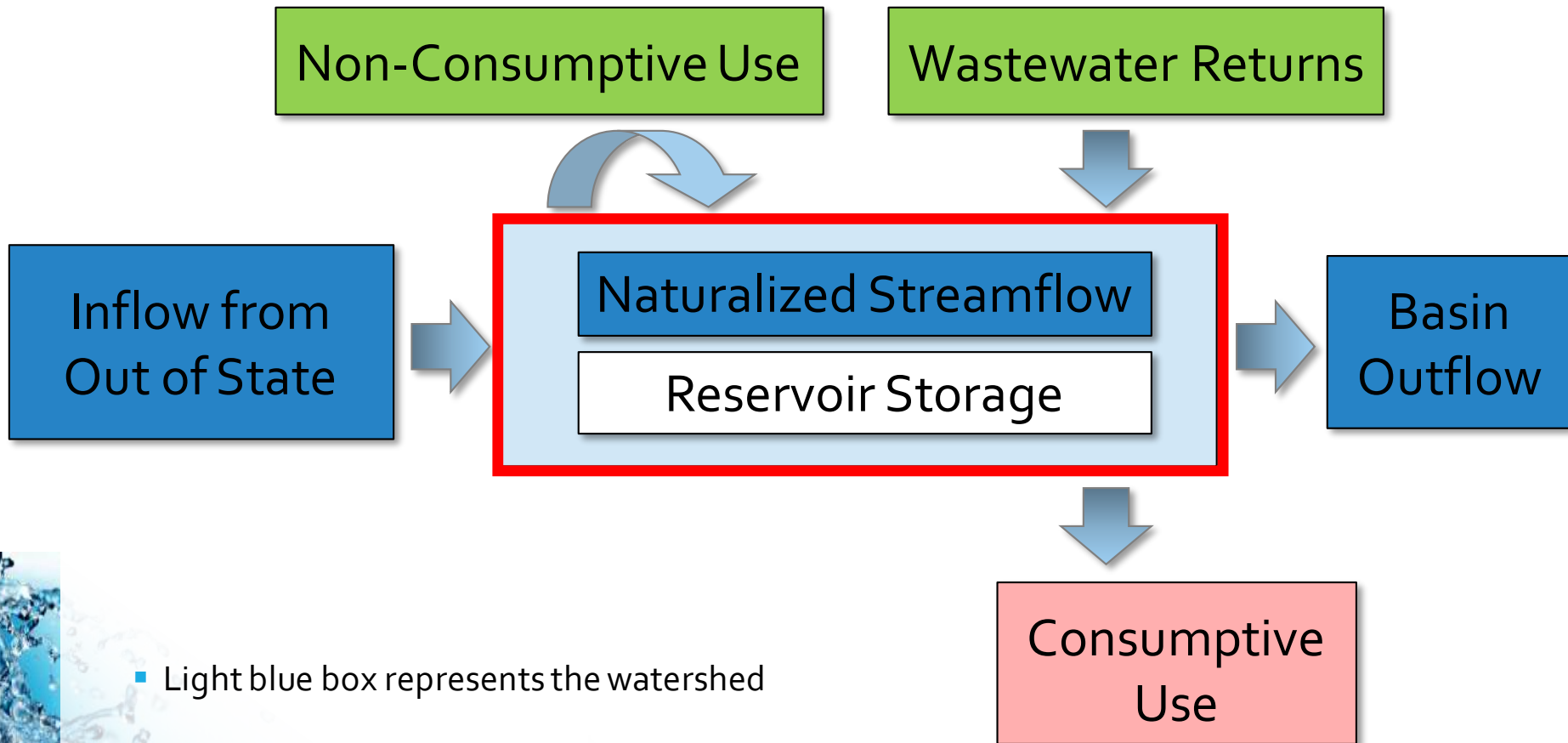
- Water budgets will be used to identify and address gaps
 - Hydrologic gaps – not anticipated at HUC 4 level for current conditions
 - Monthly analyses for drought years may yield some gaps
 - Infrastructure gaps
- The infrastructure task will use budgets to identify potential sources of water for dry areas
- The water budgets will be used as part of future scenario planning



Water Budget



Water Budget

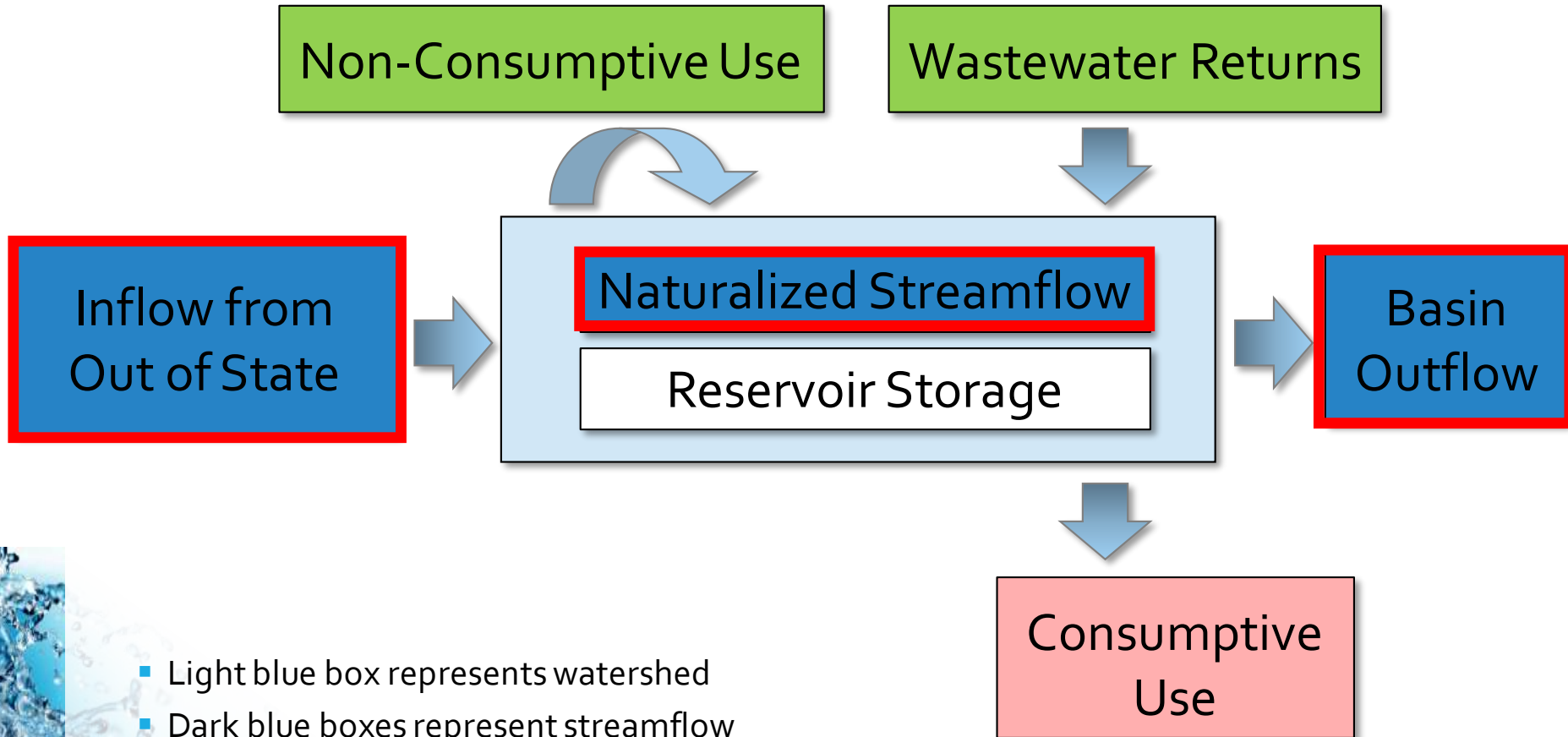


- Light blue box represents the watershed

Watershed – Chariton-Grand HUC 4

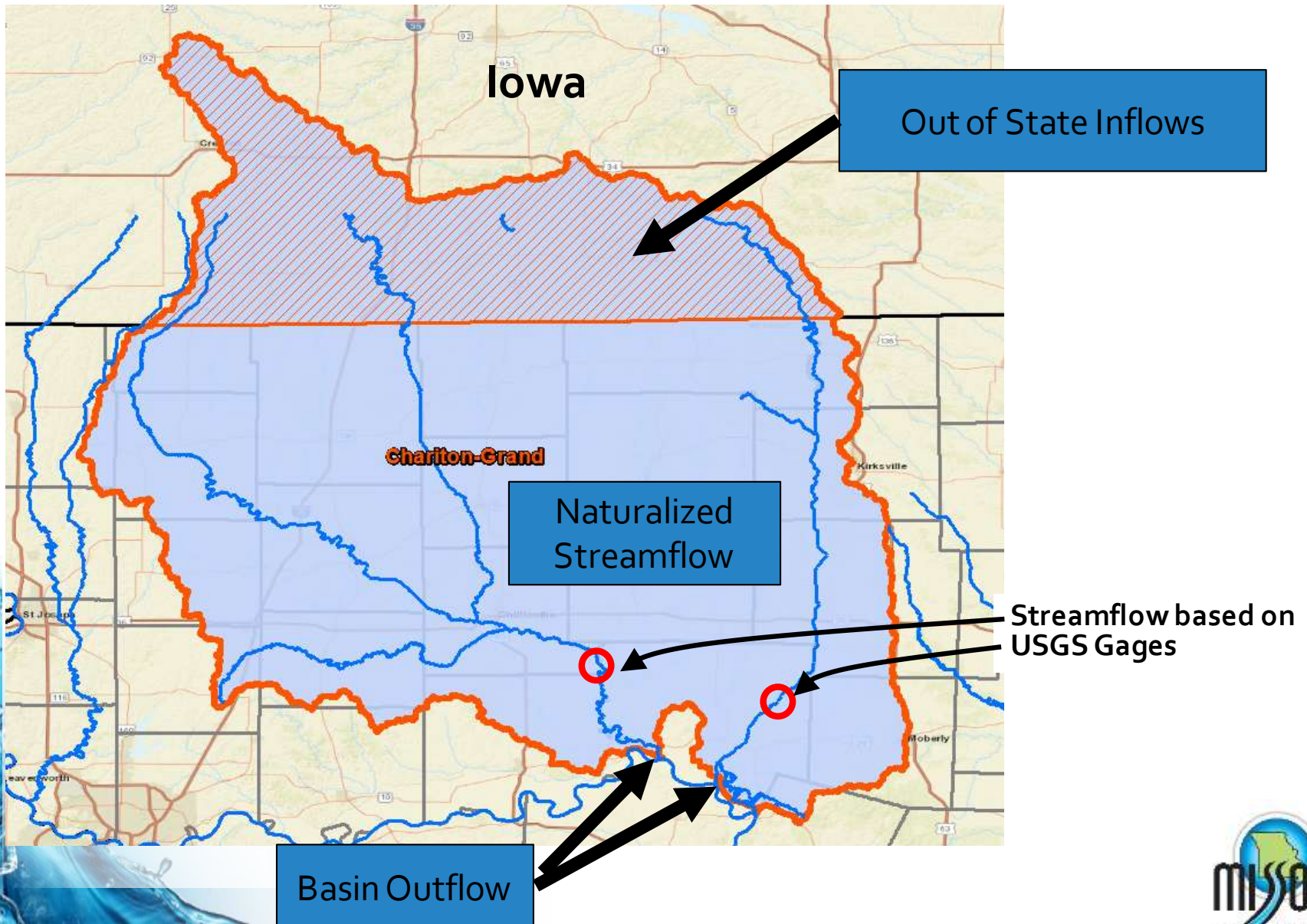


Water Budget

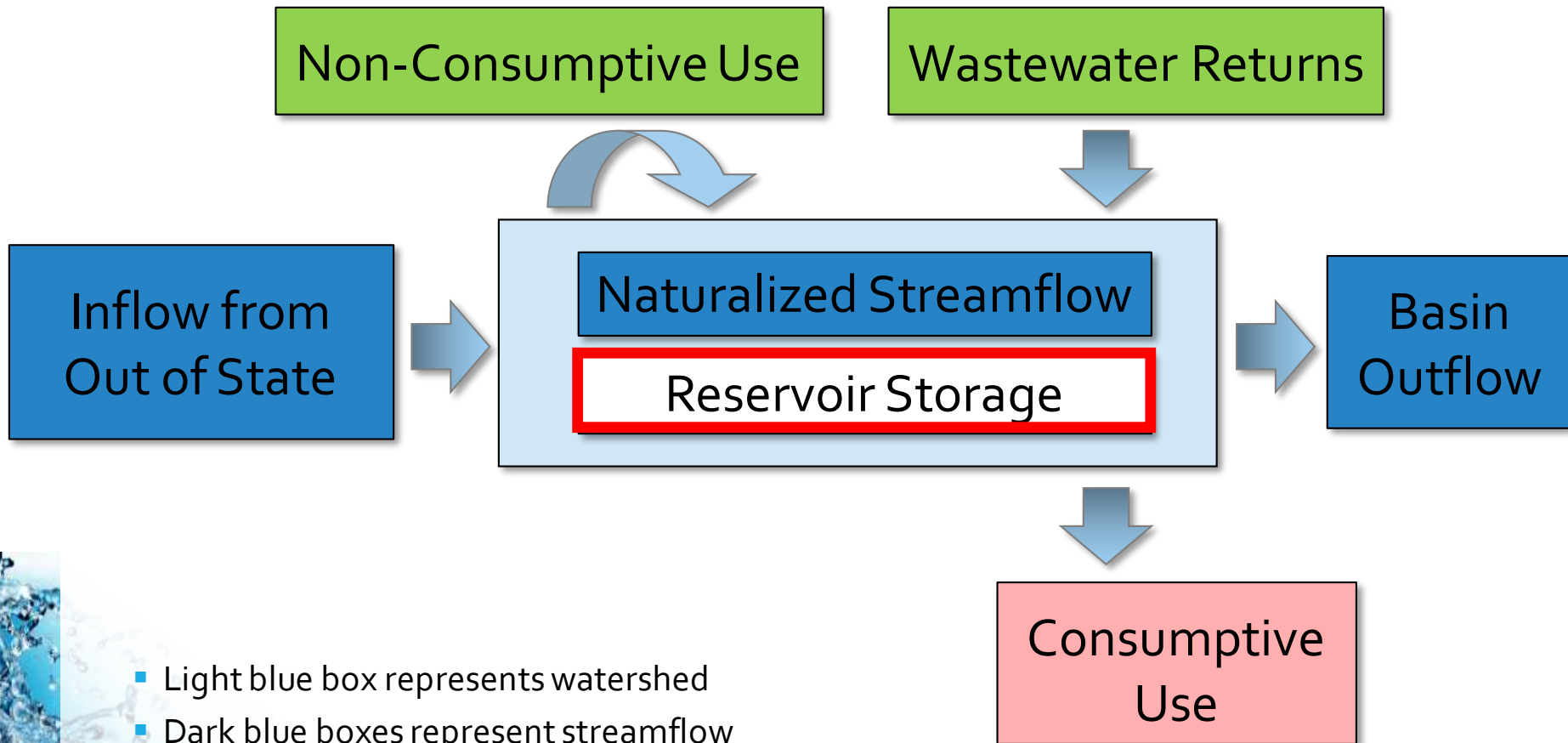


- Light blue box represents watershed
- Dark blue boxes represent streamflow

Watershed Example – Streamflows

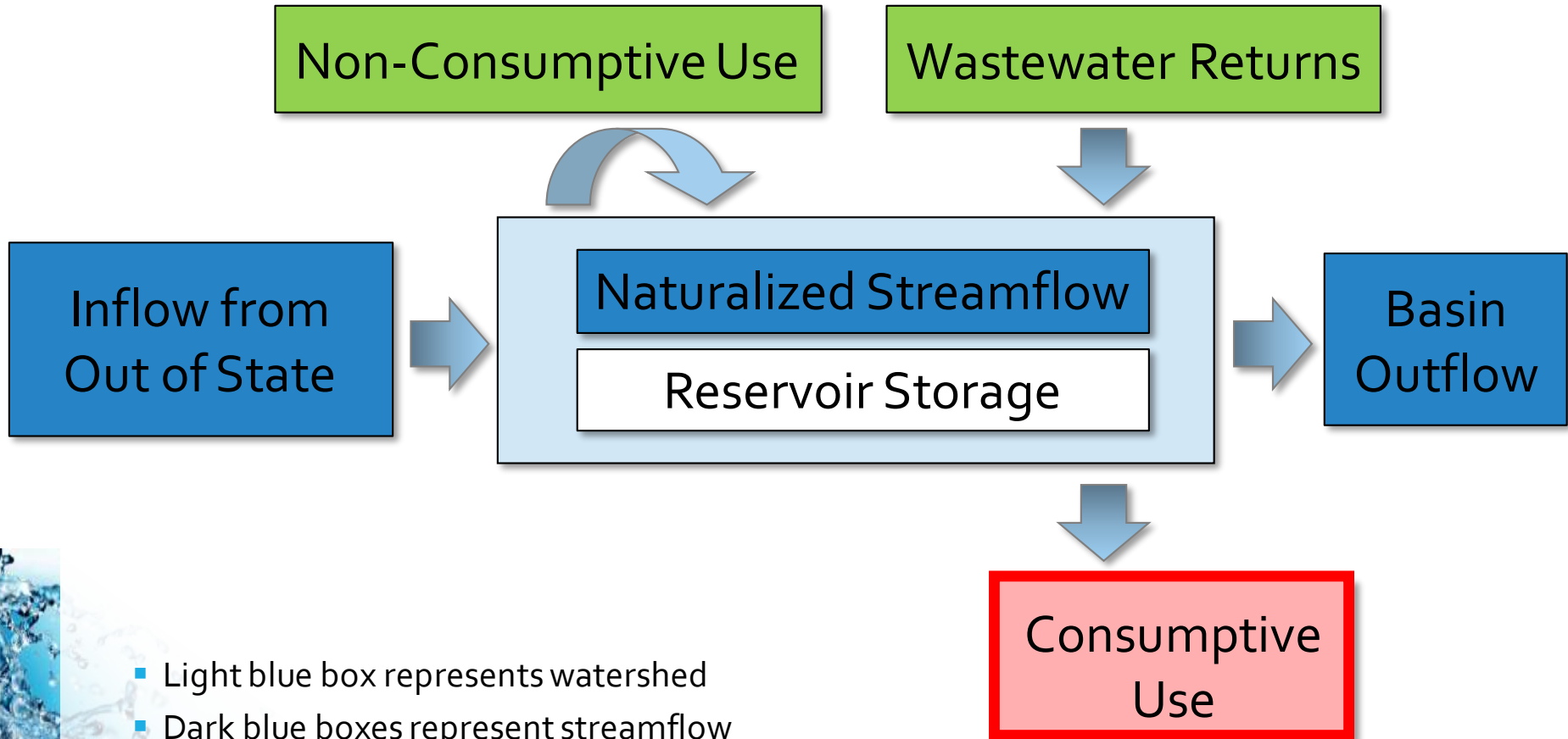


Water Budget



- Light blue box represents watershed
- Dark blue boxes represent streamflow
- White box represents reservoir storage

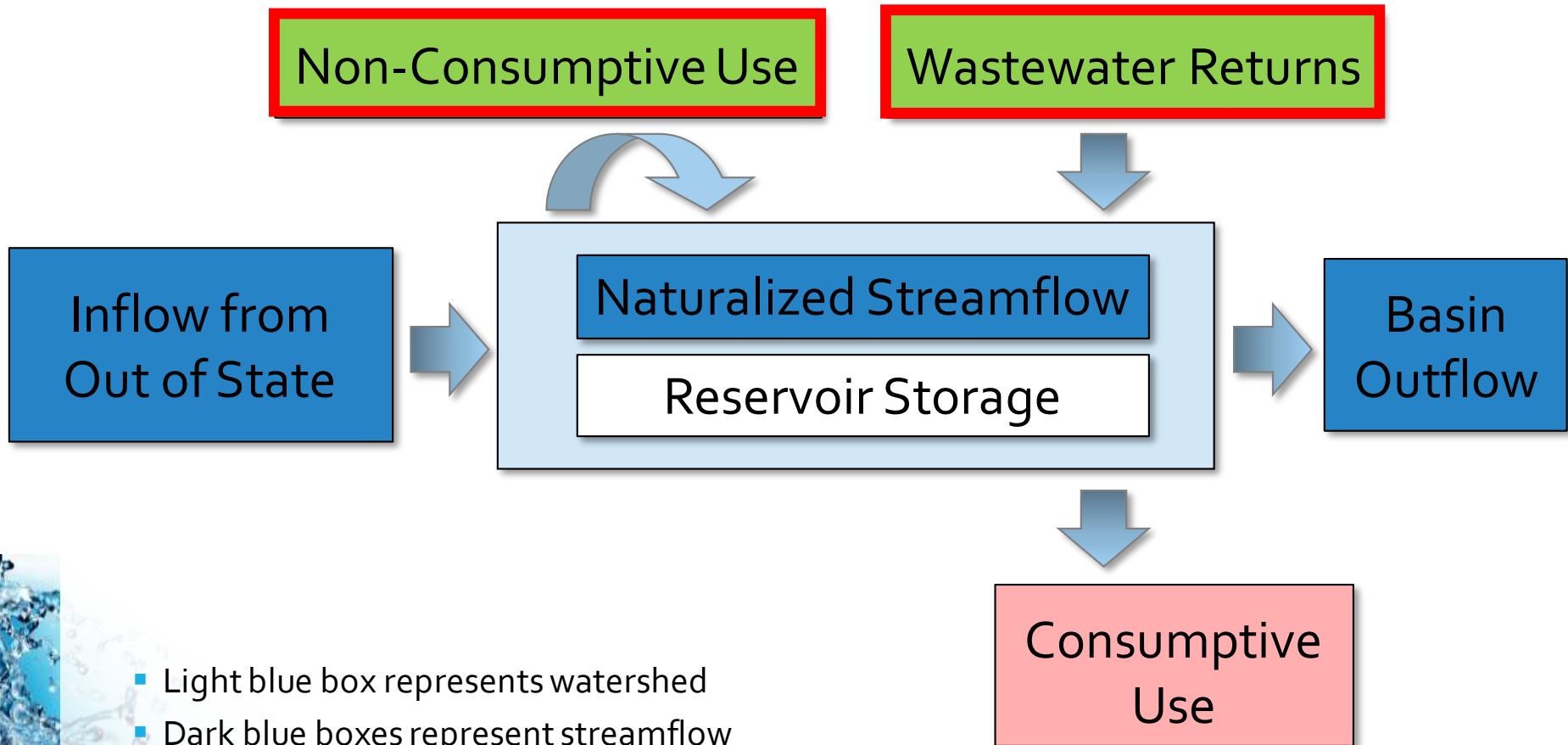
Water Budget



- Light blue box represents watershed
- Dark blue boxes represent streamflow
- White box represents reservoir storage
- Red box represents water losses

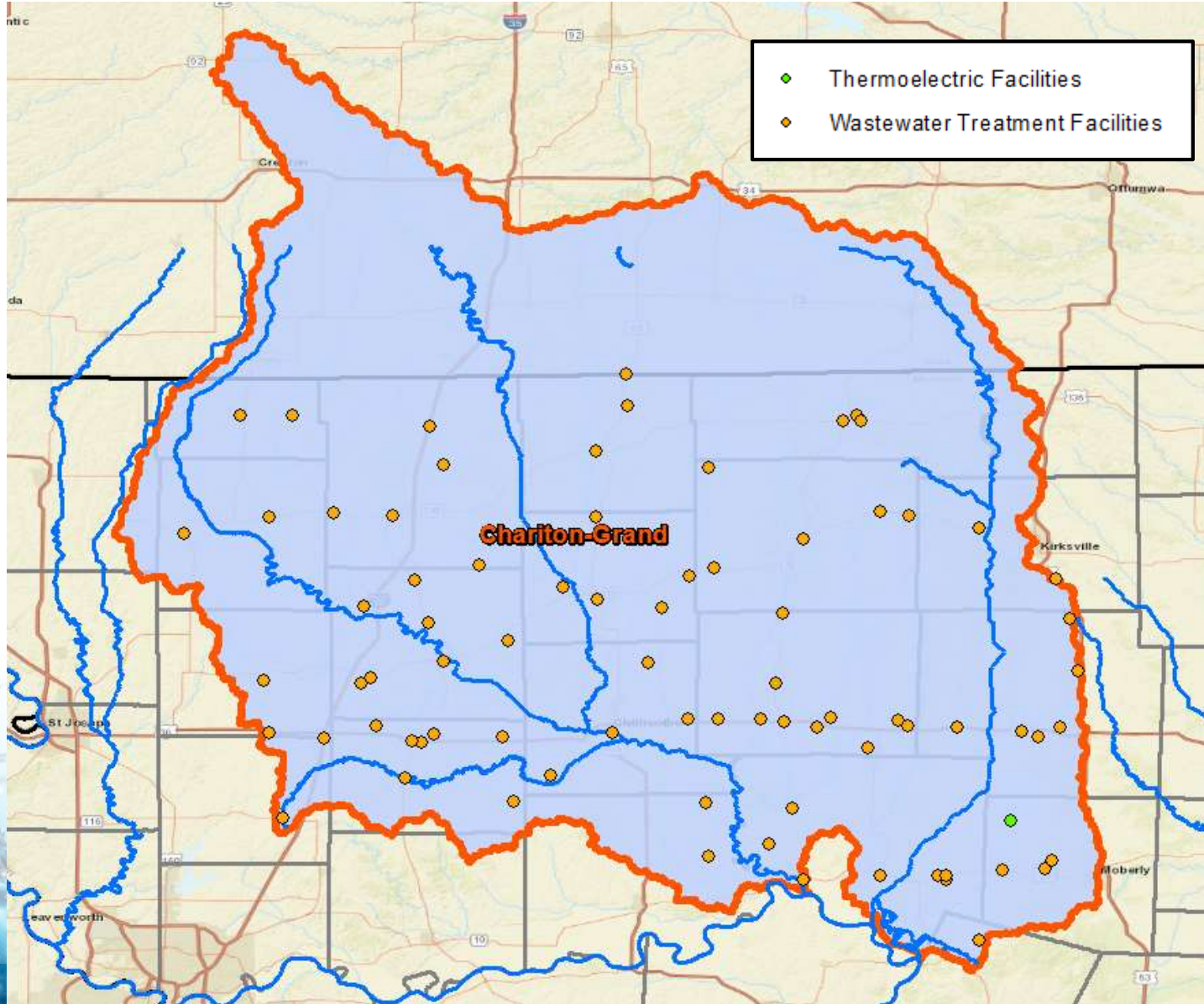


Water Budget



- Light blue box represents watershed
- Dark blue boxes represent streamflow
- White box represents reservoir storage
- Red box represents water losses
- Green boxes represent water returns

Watershed Example – Non-consumptive Use



Future Outcomes and Schedule

- Results of gap analysis will feed into Infrastructure task
- Areas with highest future demands identified and/or gaps may be investigated in more detail at HUC 8 level
- Full presentation of results of HUC 4 budgets presented to all workgroups in May



Water Quality



Water Quality Task Summary

Goals

- Recognize water quality and assess how this affects water supply uses

Elements

- Analyze statewide water quality and the impact on consumptive water supplies
- Evaluate water quality for assessment of wastewater improvements

Considerations

- Not intended as a regulatory plan
- Water quality regulations are authorized under different regulatory statutes than those that authorize the development of the statewide water resources plan

Water Quality Methodology Overview



Data Compilation

Summarize Current Statewide Water Quality

Assess Spatial Trends and Identify Regional Areas of Concern

Assess Trends in Water Quality Over Time

Additional Water Quality Discussion

Develop Water Quality Report

Components of Water Quality Analysis

Introduction

Setting and Climate

Physiography

Surface Water Quality

- ⑩ General statewide discussion
- ⑩ HUC₄ / major basins-level discussion
- ⑩ Temporal trends
- ⑩ Prioritization of watersheds / regions
- ⑩ Focus on water quality impacts to water supply



Components of Water Quality Analysis

Groundwater Quality

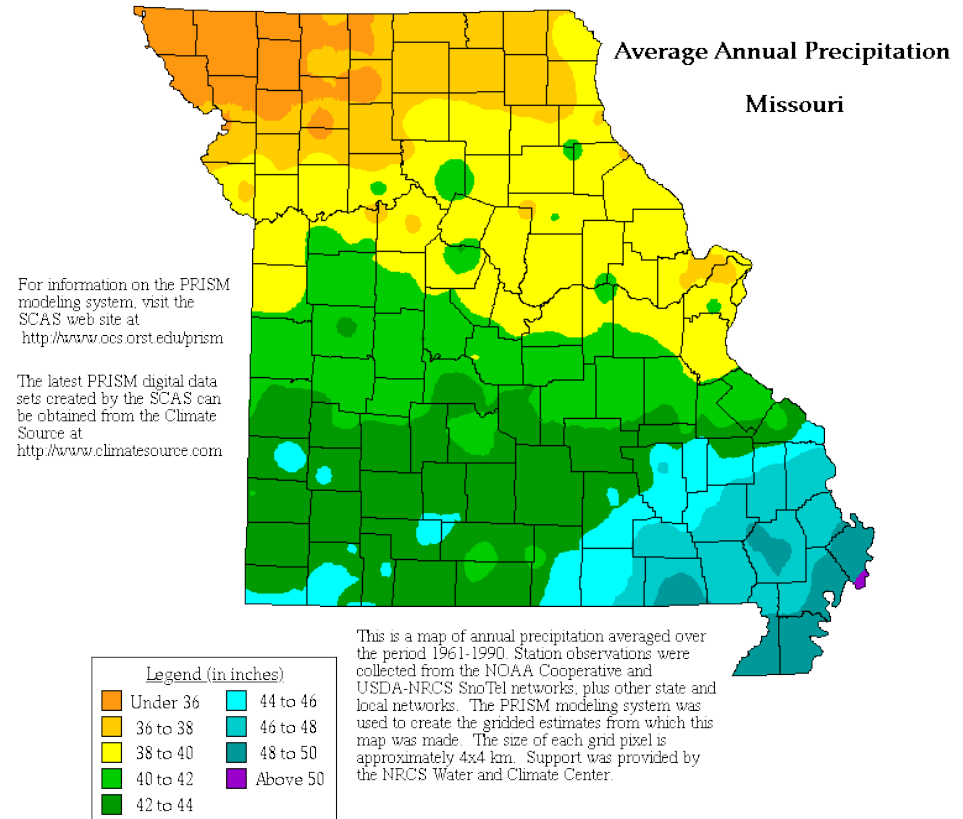
- ⑩ General statewide discussion
- ⑩ Province level discussion
- ⑩ Temporal trends
- ⑩ Focus on impacts to water supply

•Emerging Issues



Setting and Climate

- High level state-wide climate description and discussion
- Precipitation patterns
- Seasonal patterns
- Average annual runoff



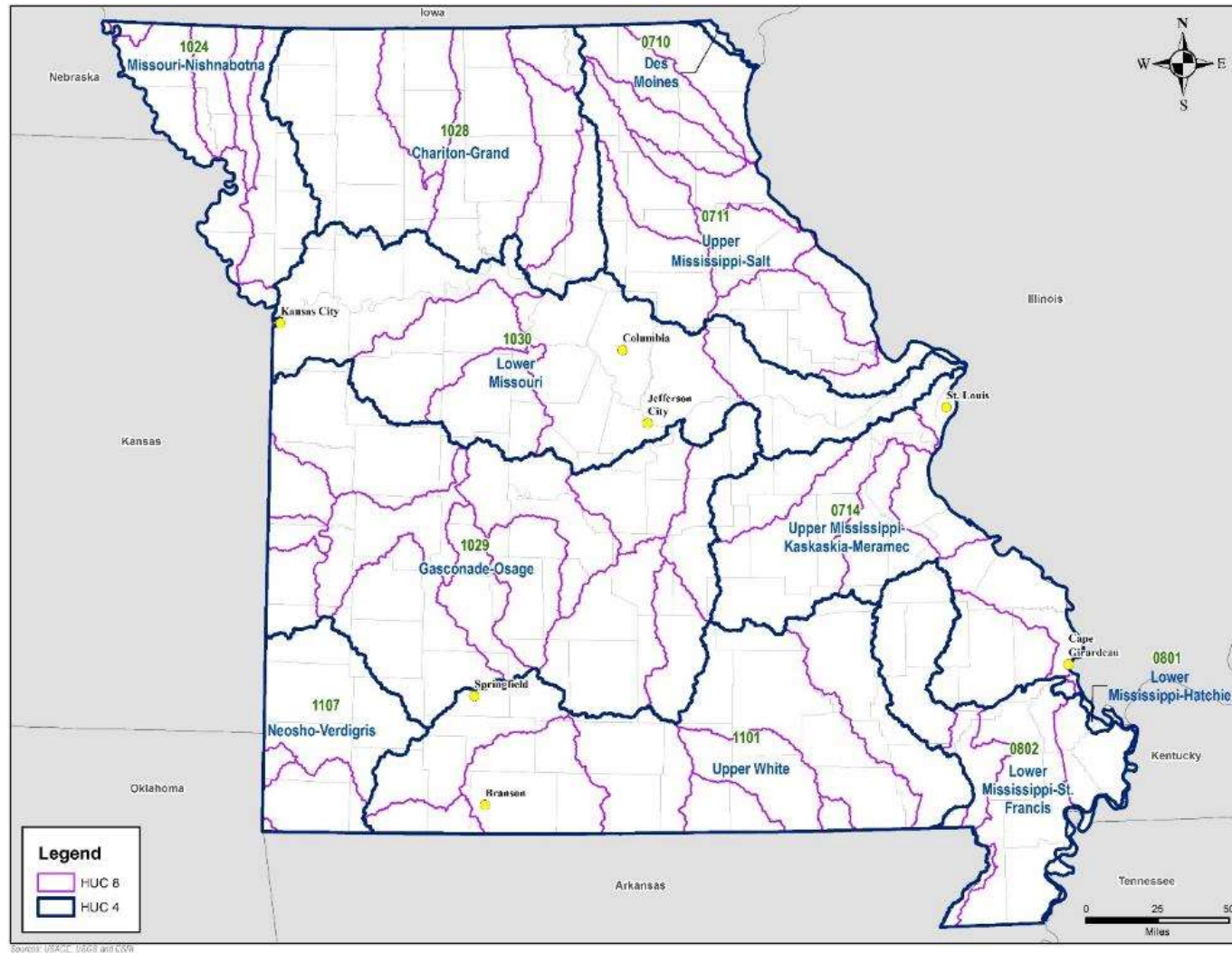
Copyright 2000 by Spatial Climate Analysis Service,
Oregon State University

Physiography

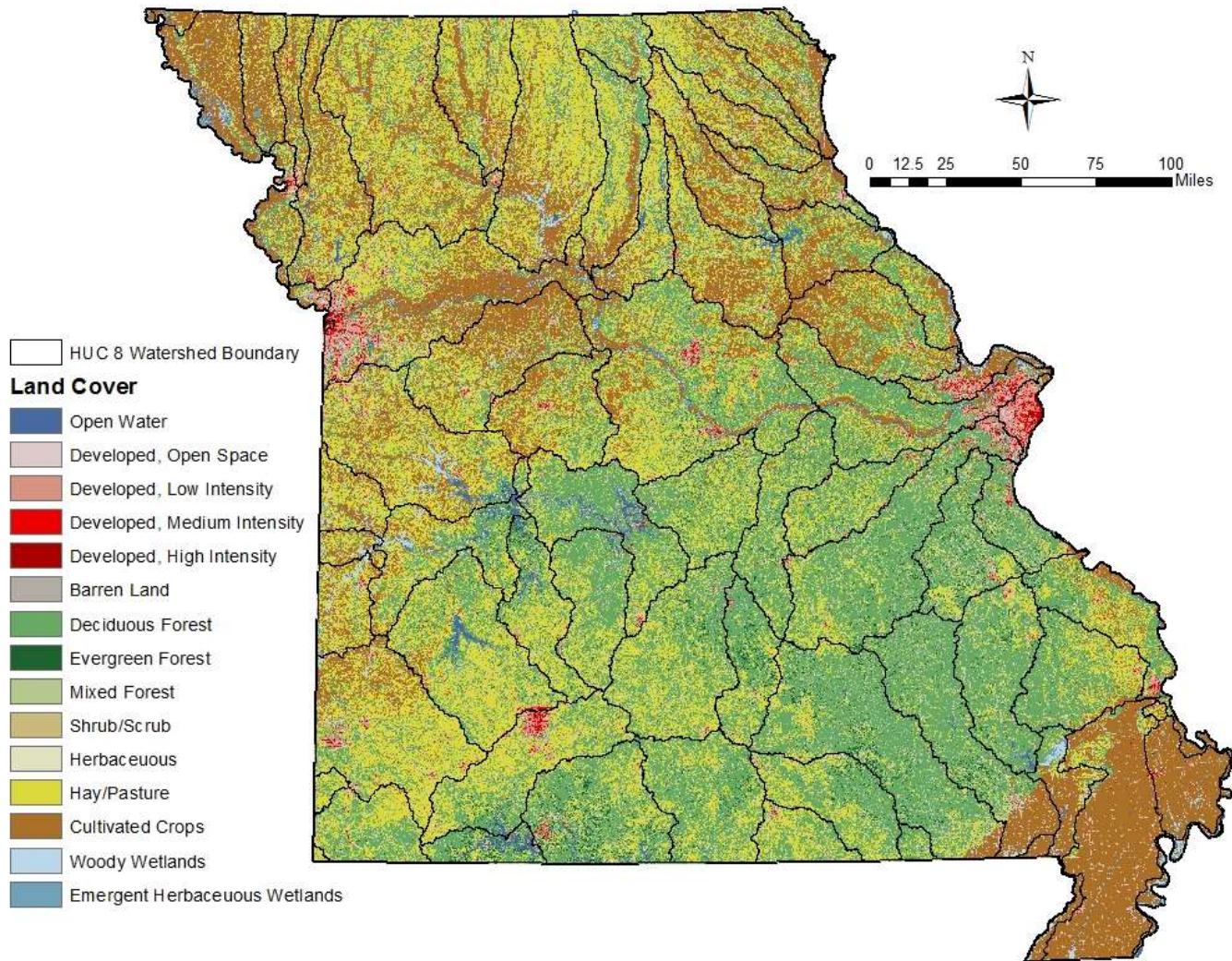
- Major watersheds
- Land use types
- Topography
- Geological formations
- Groundwater provinces



Major Watersheds



Land Cover



Surface Water Quality

General Statewide Discussion

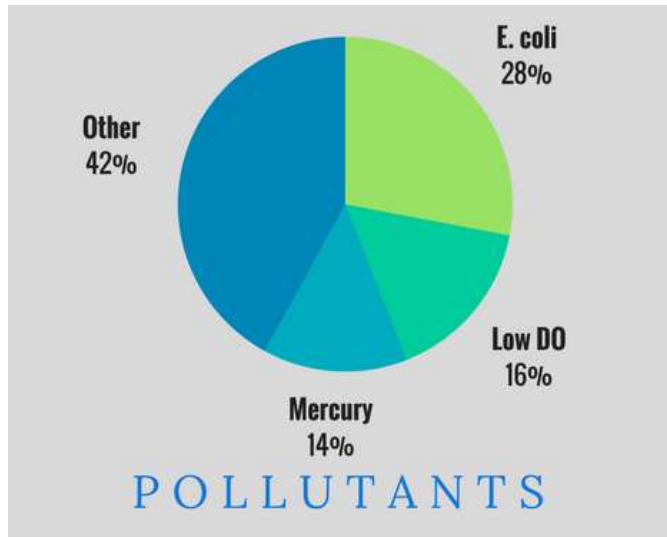
- Primary parameters of concern
- Summary of WQ monitoring in Missouri
 - Monitoring agencies, locations
 - Local studies and additional data sources
 - Volunteer monitoring programs
- Overview of surface waters designated for water supply uses
- Current impairments based on 303(d) list
- Statewide changes in 303(d) listings over time
 - Changes in regulatory focus



Primary Parameters of Concern

Parameter	Primary Sectors Impacted		
	Supply	Wastewater	Recreation & Aesthetics
Ammonia		x	
Bacteria (E. coli)	x	x	x
Chloride	x	x	
Low Dissolved Oxygen		x	
Metals (cadmium, copper, lead, manganese, nickel, zinc)	x	x	
Nitrates	x		
Nutrients (nitrogen, phosphorus)	x	x	x
Pesticides (atrazine, others)	x		
Radiologicals (gross alpha)	x		
Sulfates		x	
Total Suspended Solids	x	x	x

MoDNR 2016 303(d) List Summary

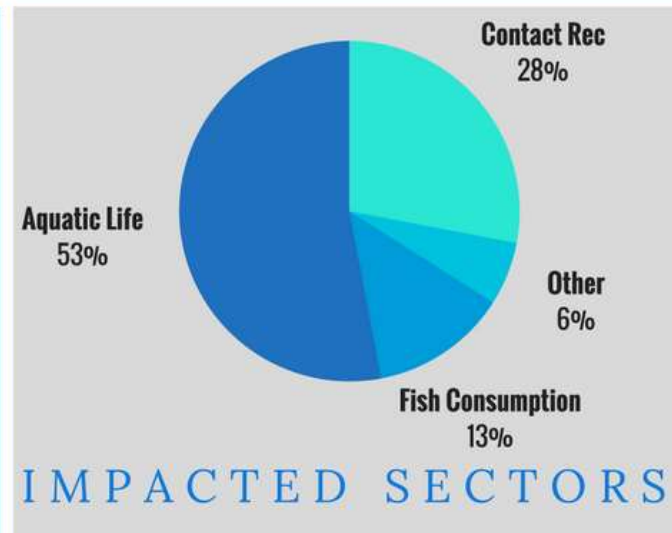


452

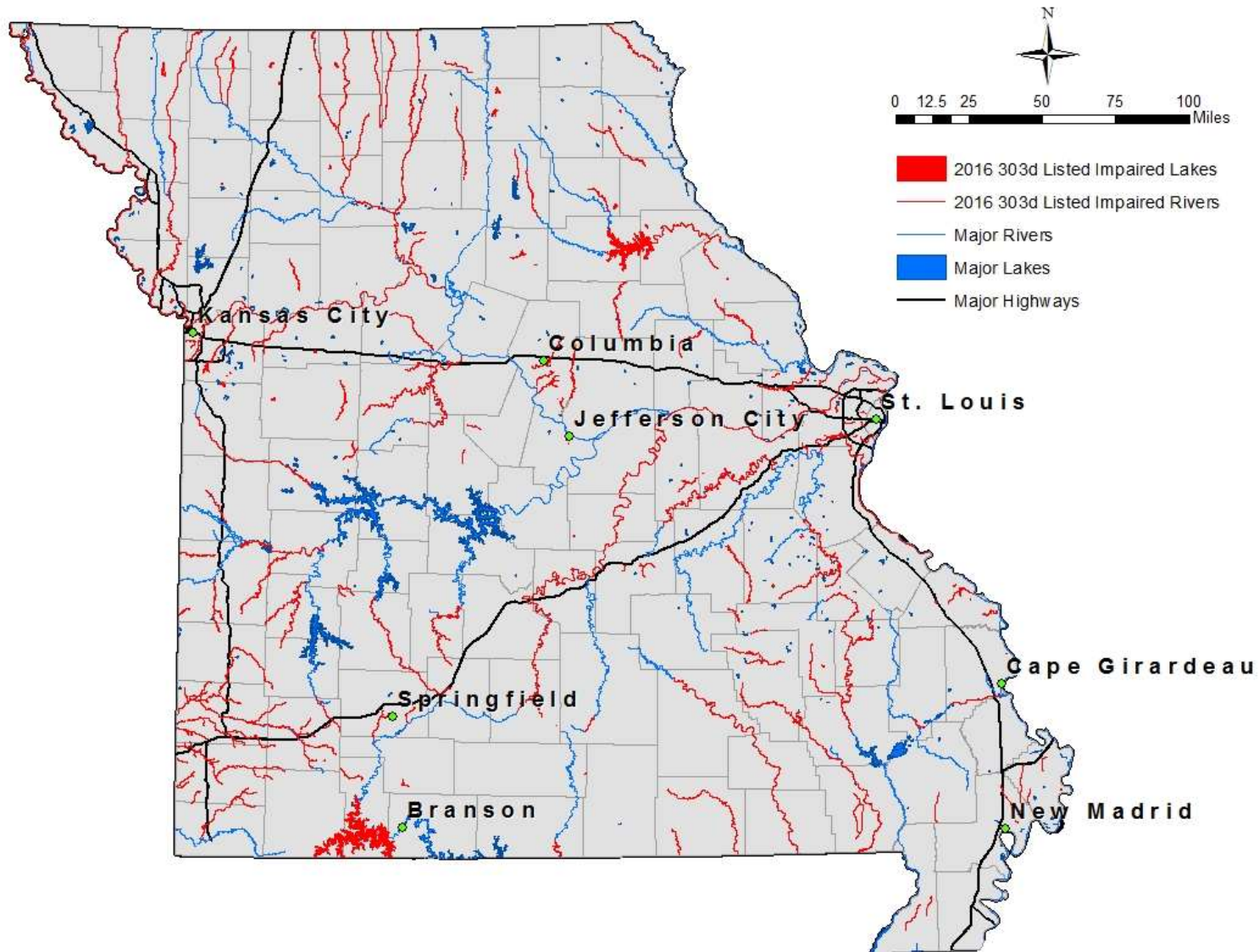
IMPAIRMENTS

75

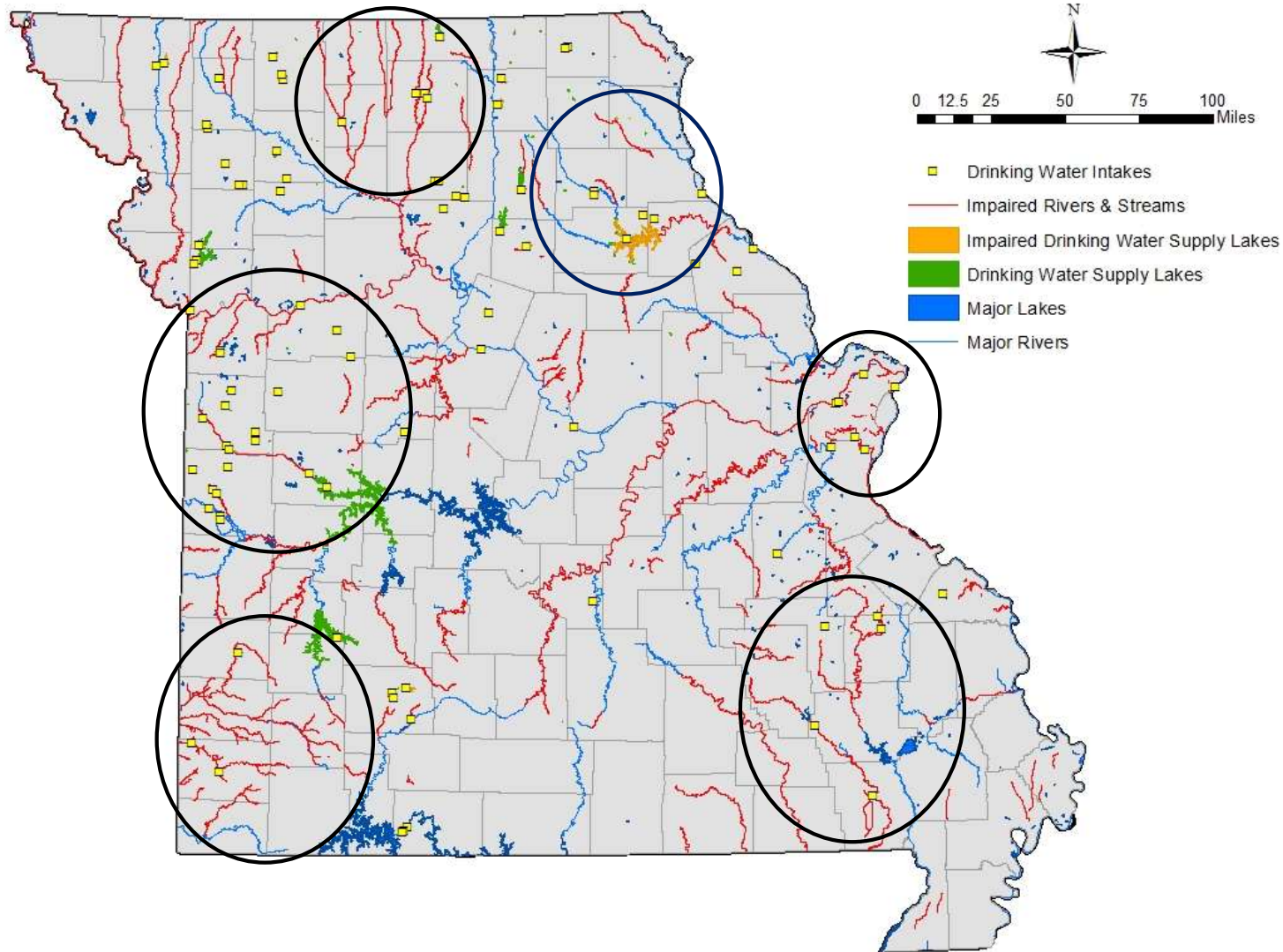
NEW LISTINGS



MoDNR 2016 303(d) Listed Impaired Waters



Impacts to Public Drinking Water Supplies



MoDNR 2016 303(d) List Summary of Impairment Causes

Pollutant	Impaired Stream Miles	Impaired Lake Acreage
Ammonia	72	-
Cadmium	255	-
Chloride; SO ₄ +Cl ⁻	66	-
Copper	9	-
Nickle	42	-
Low DO	960	-
TSS	46	-
Zinc	247	-
Nutrients*	3.5	41,747
Nitrogen	-	42,997
Phosphorus	-	2,631
Lead	463	-
Bacteria (<i>E. coli</i>)	2,356	-
Atrazine	-	35

**Nutrient/eutrophication biological indicator impairment from municipal point sources*

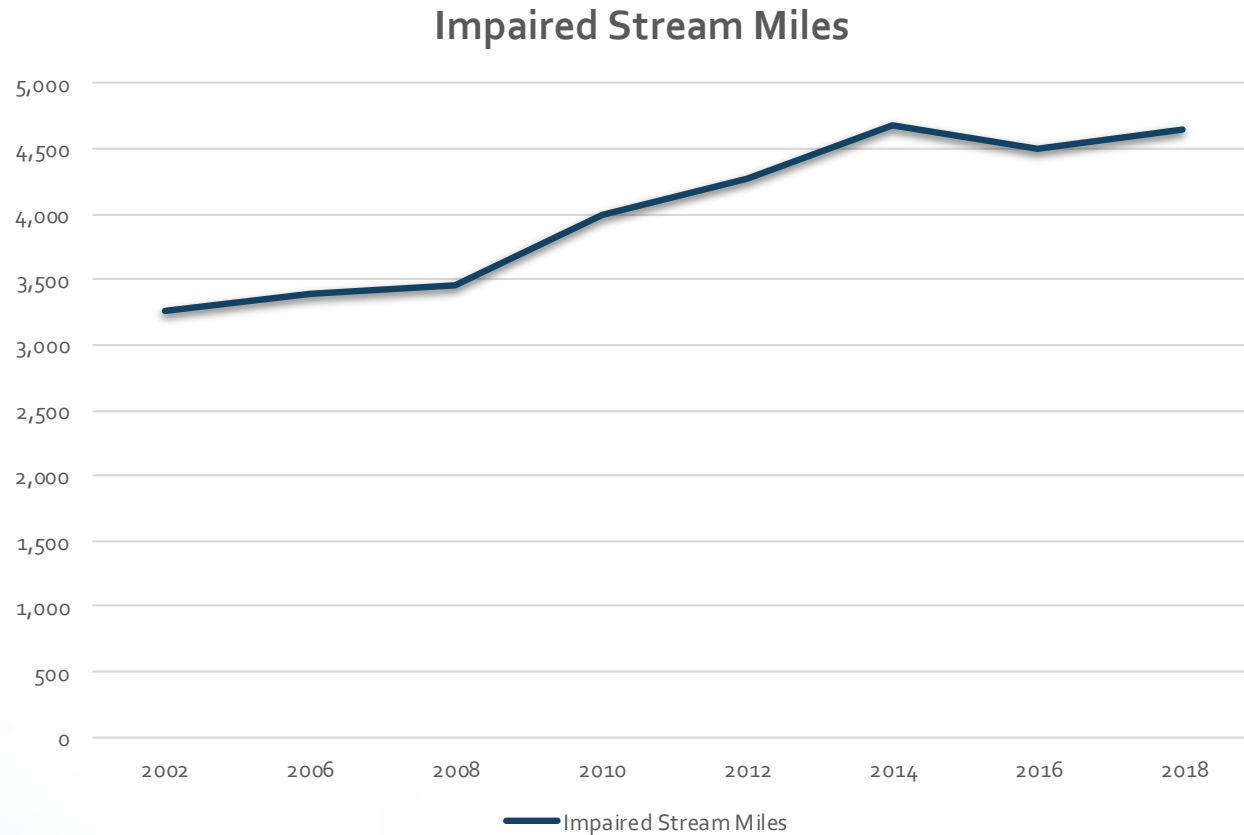
Changes to 303(d) Listings: 2002-2018

Assessment Period	Total # of Listings	Impaired ¹ Stream Miles	Impaired Lake ¹ Acreage	Primary Impairments
2002	223	3,260	89,563	Mercury, TSS, Nutrients
2004-2006	228	3,390	63,526	Low DO, Bacteria, Mercury
2008	296	3,459	66,660	Low DO, Bacteria, Mercury
2010	353	3,990	172,167	Low DO, Bacteria, Mercury
2012	351	4,271	67,586	Bacteria, Low DO, Mercury
2014	395	4,680	68,139	Bacteria, Low DO, Mercury
2016	452	4,506	70,439	Bacteria, Low DO, Mercury
2018 ²	470	4,649	69,715	<i>Bacteria, Low DO, Mercury</i>

¹ Some streams/lakes have multiple impairments resulting in total impaired miles/acres to include the same water body more than once

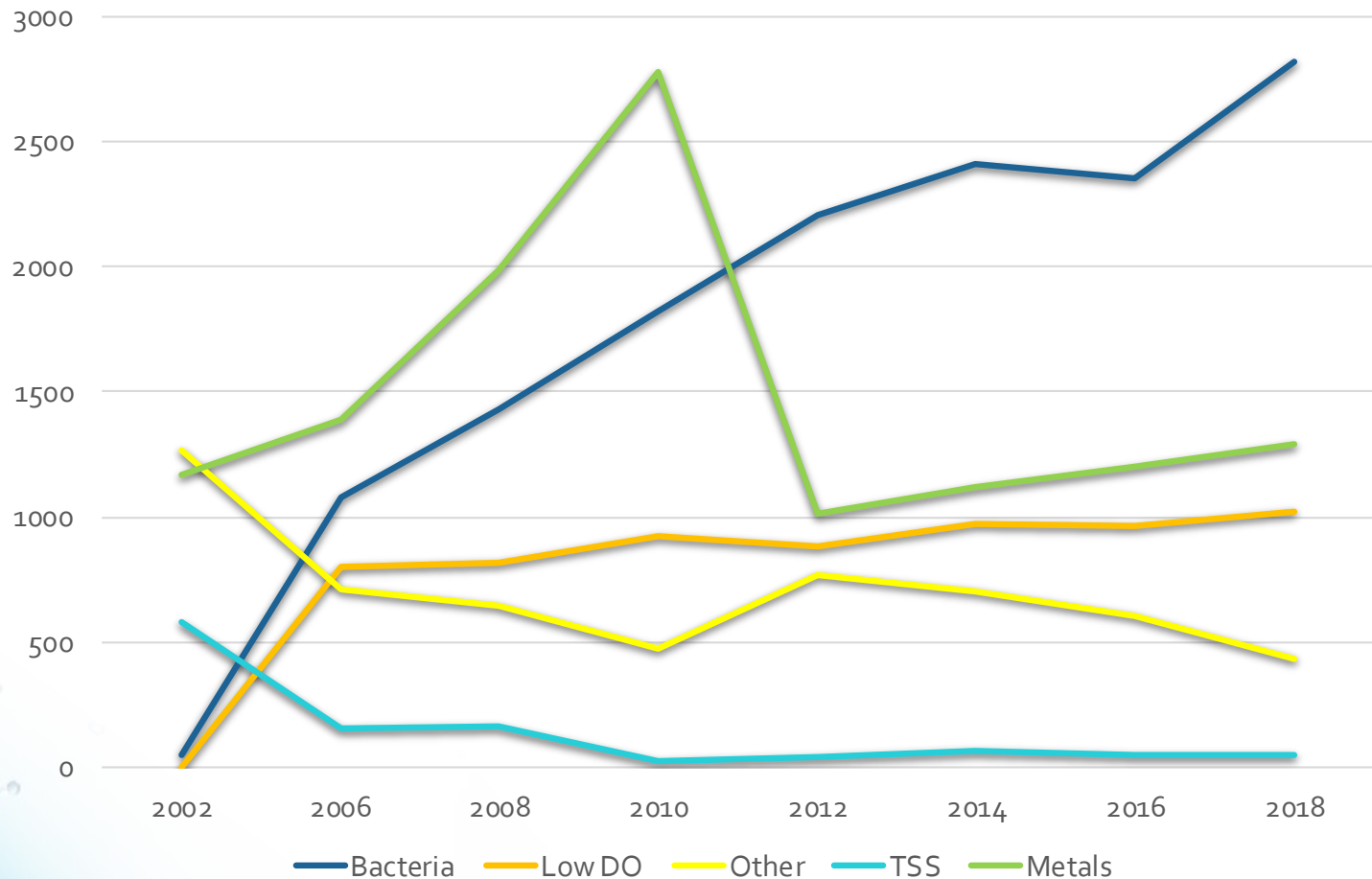
² Pending EPA approval

Changes to 303(d) Listings: 2002-2018



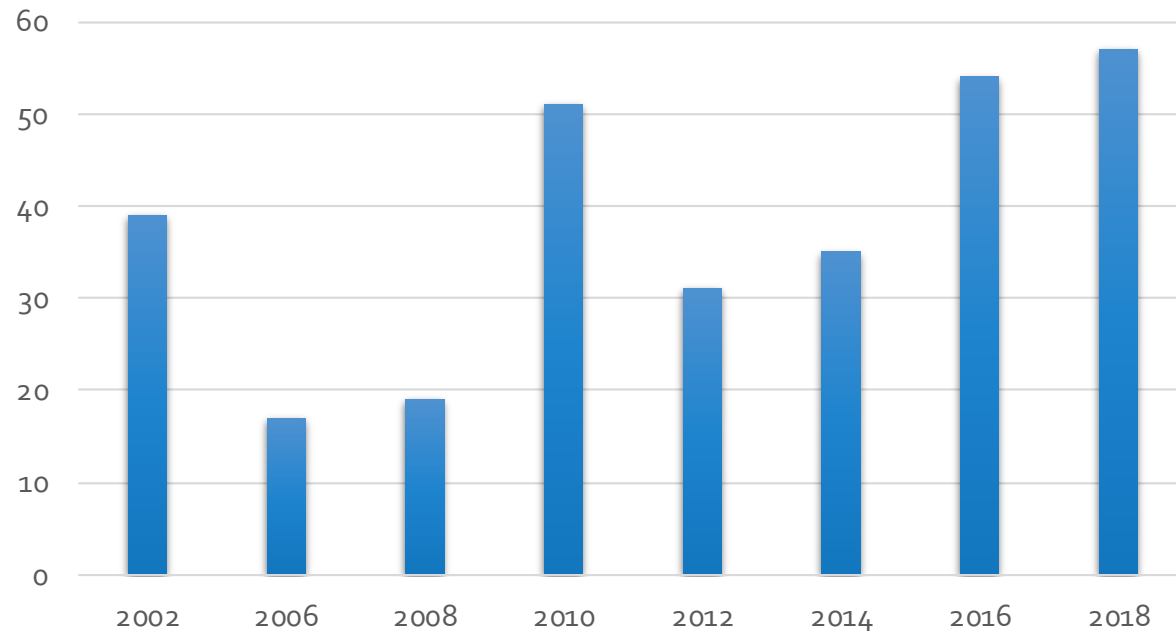
Changes to 303(d) Listings: 2002-2018

Impaired Stream Miles



Changes to 303(d) Listings: 2002-2018

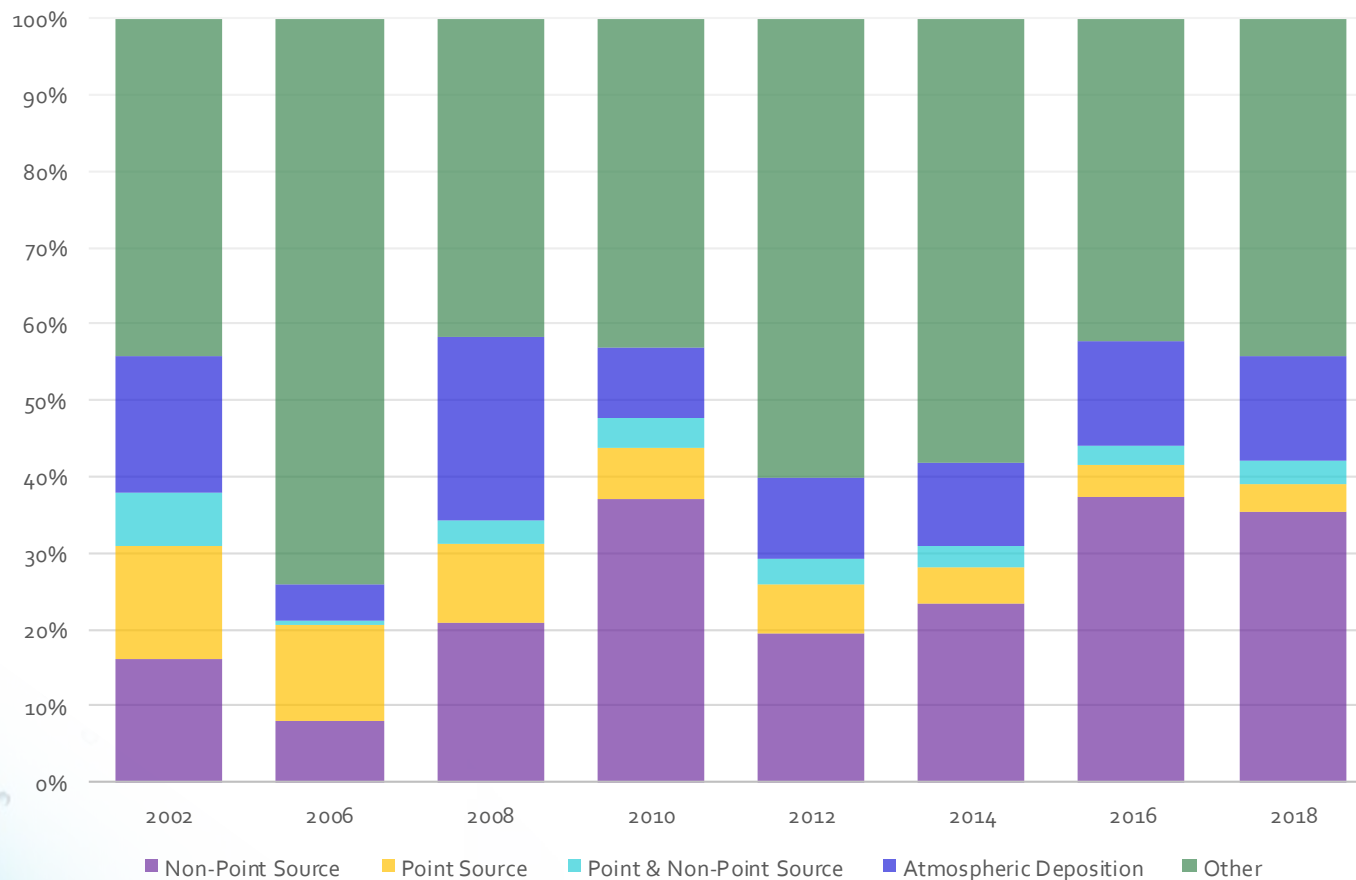
Number of Impaired Lakes



- Water quality standards for nitrogen, phosphorus, and chlorophyll *a* were implemented in 2010

Changes to 303(d) Listings: 2002-2018

303(D) LISTED POLLUTION SOURCES

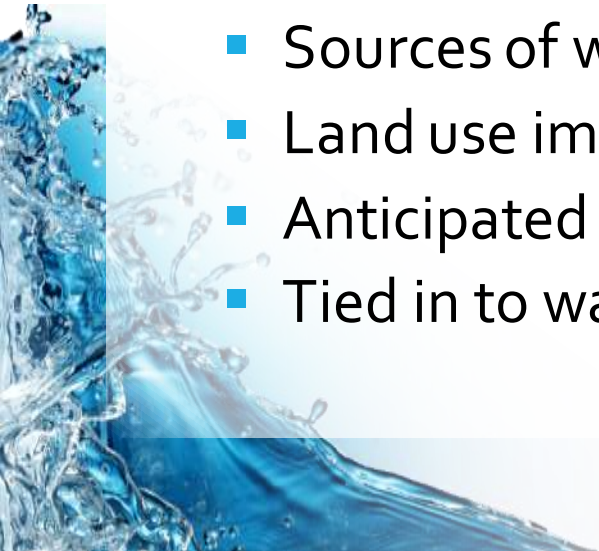


** Other field includes agricultural, industrial, toxic waste/superfund, physical modifications, natural, and unknown sources*

Surface Water Quality

HUC₄ / Major Basins-Level Discussion

- Spatial trends
 - Sources
 - Parameters
 - Uses
- Area-specific issues
 - Prevalence of public water supply
 - Primary uses of surface water in region
- Sources of water quality concerns
- Land use impacts
- Anticipated population growth/land use changes
- Tied in to water supply and demand analyses



Surface Water Quality

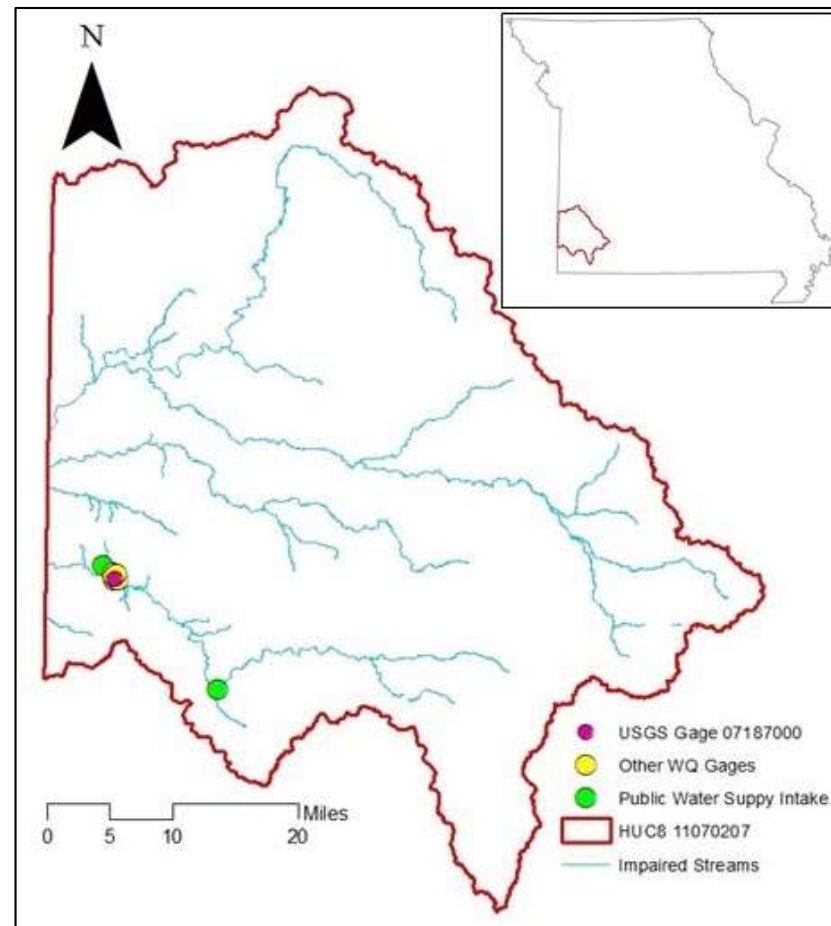
Temporal Trend Analysis

- Focus on impacts to water supply
- Methodology
 - Account for impacts of variable flow
 - Linear regression to isolate flow influence
 - Flow-weighted concentrations
 - Account for impacts of seasonal variability
 - Kendall test for seasonality
- Data limitations
 - Need long periods of record
 - Regular and consistent sampling regime
 - Co-located flow and water quality data



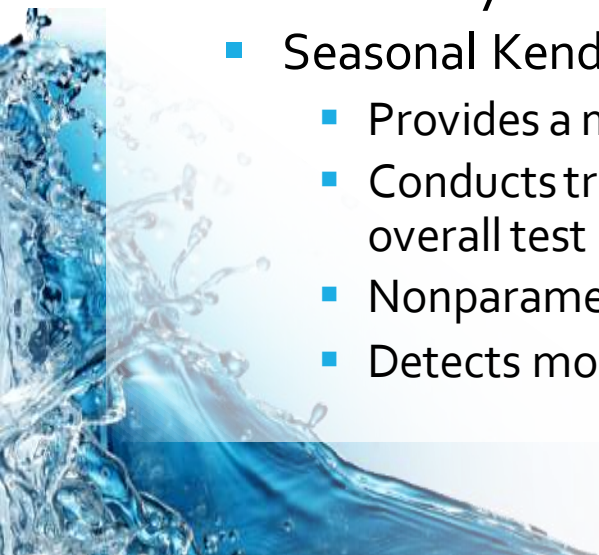
Temporal Trend Analysis

- Pilot Site - Shoal Creek
- Public Drinking Water Supply
- Impaired For:
 - Metals (Cd, Pb, Zn)
 - Bacteria
 - Nutrients
 - Dissolved Oxygen
- Multiple Data Sources
 - MoDNR
 - NCHD
 - USEPA
 - USGS (gage 07187000)
- Consecutive monthly data available from Jan 2009 – Dec 2017

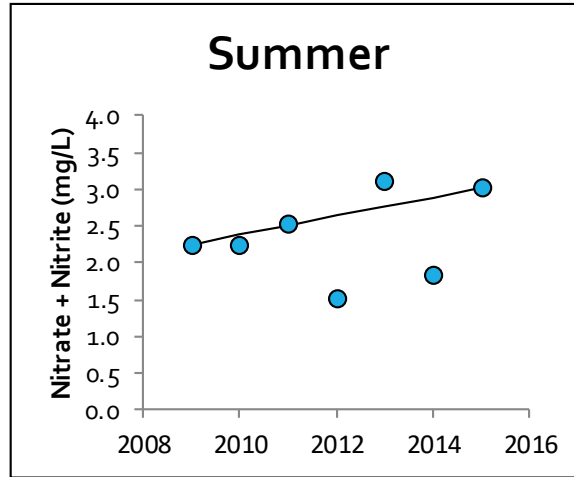
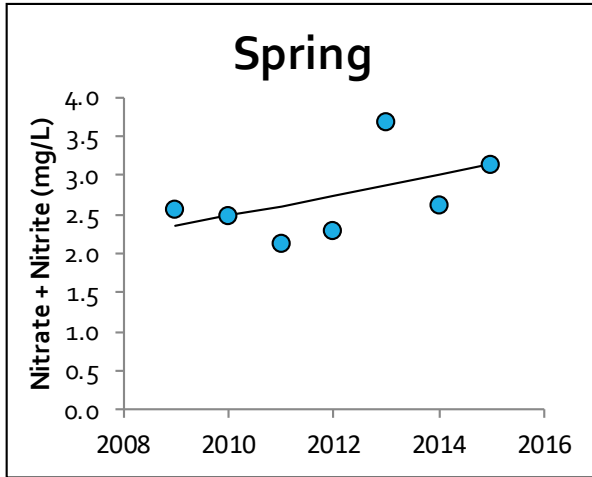


Temporal Trend Analysis

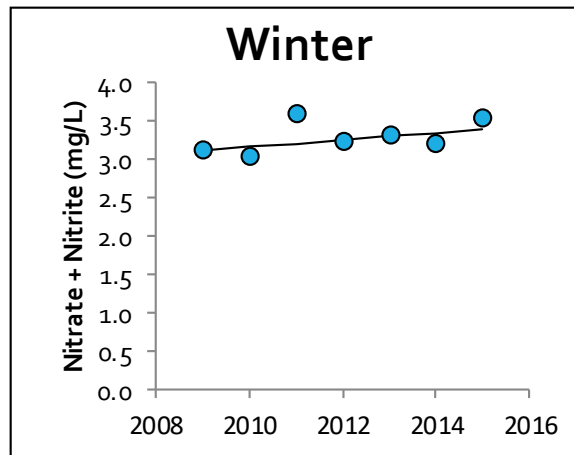
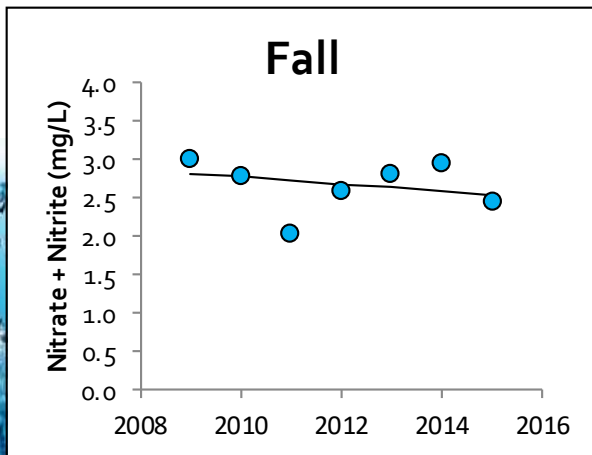
- Influence of Flow Variability on WQ Data
 - Linear regression analyses to determine which parameters are influenced by flow
 - Concentrations standardized to flow using equations based on the regressions
 - Flow-influenced parameters adjusted by subtracting the flow-based concentrations
 - Flow-adjusted concentrations can then be analyzed for seasonality
- Seasonality
 - Seasonal Kendall test
 - Provides a measure change over time independent of season effects
 - Conducts trend test within each season, then combines to form one overall test
 - Nonparametric
 - Detects monotonic and linear trends



Shoal Creek Temporal Trend Analysis



Mann-Kendall trend test	
Kendall's tau	0,810
S	8327,000
p-value	< 0,0001
alpha	0,05

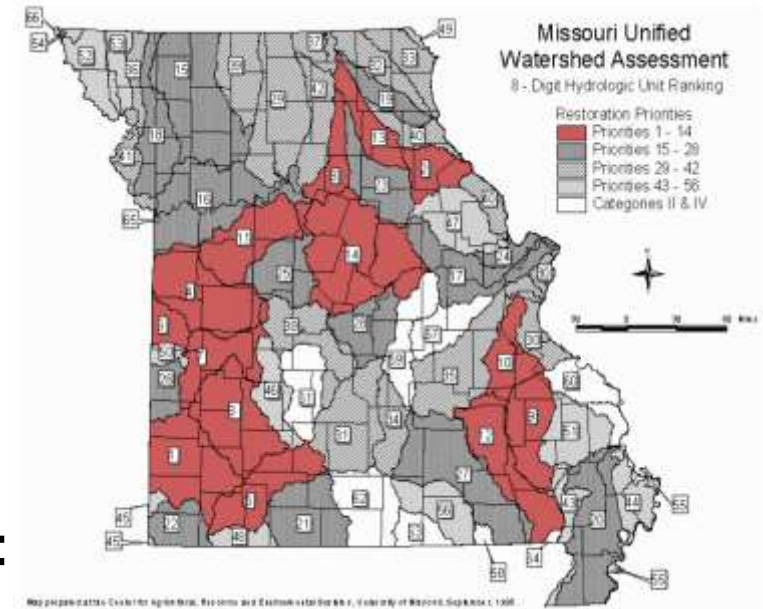


Seasonal Kendall tests identify long-term trends for parameters that vary seasonally

Surface Water Quality

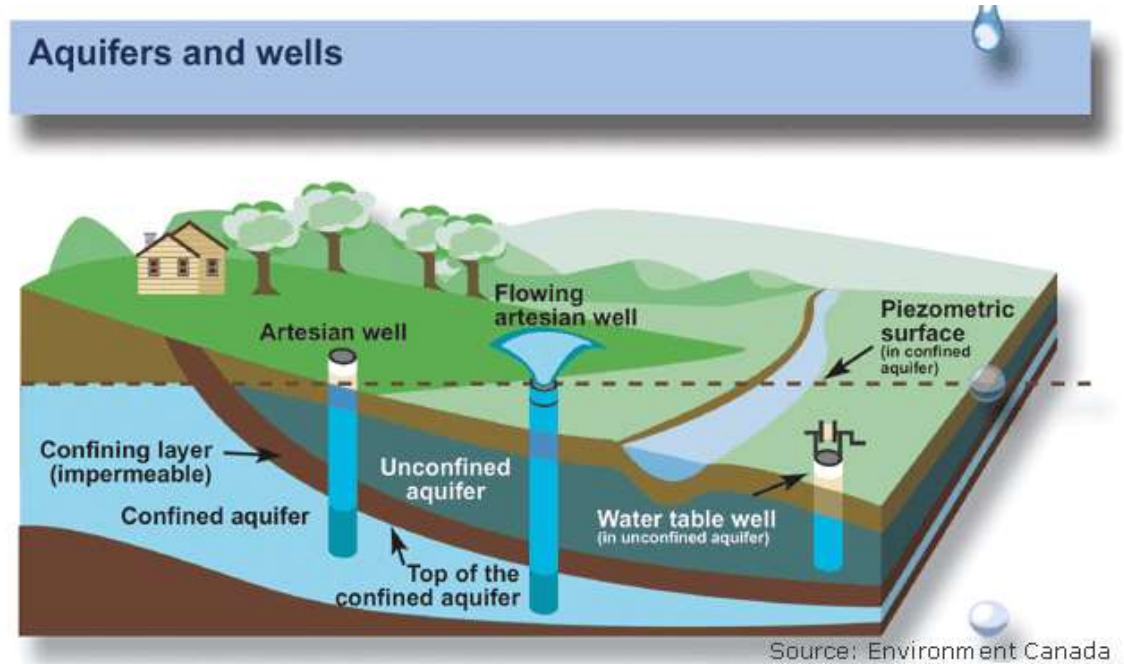
Prioritization of WQ issues by HUC 8

- Similar to 1998 Unified Watershed Assessment
 - Not all metrics are relevant and repeatable
 - Focus on water supply impacts
- Map of priority areas based on:
 - Impairments
 - Uses
 - Trends

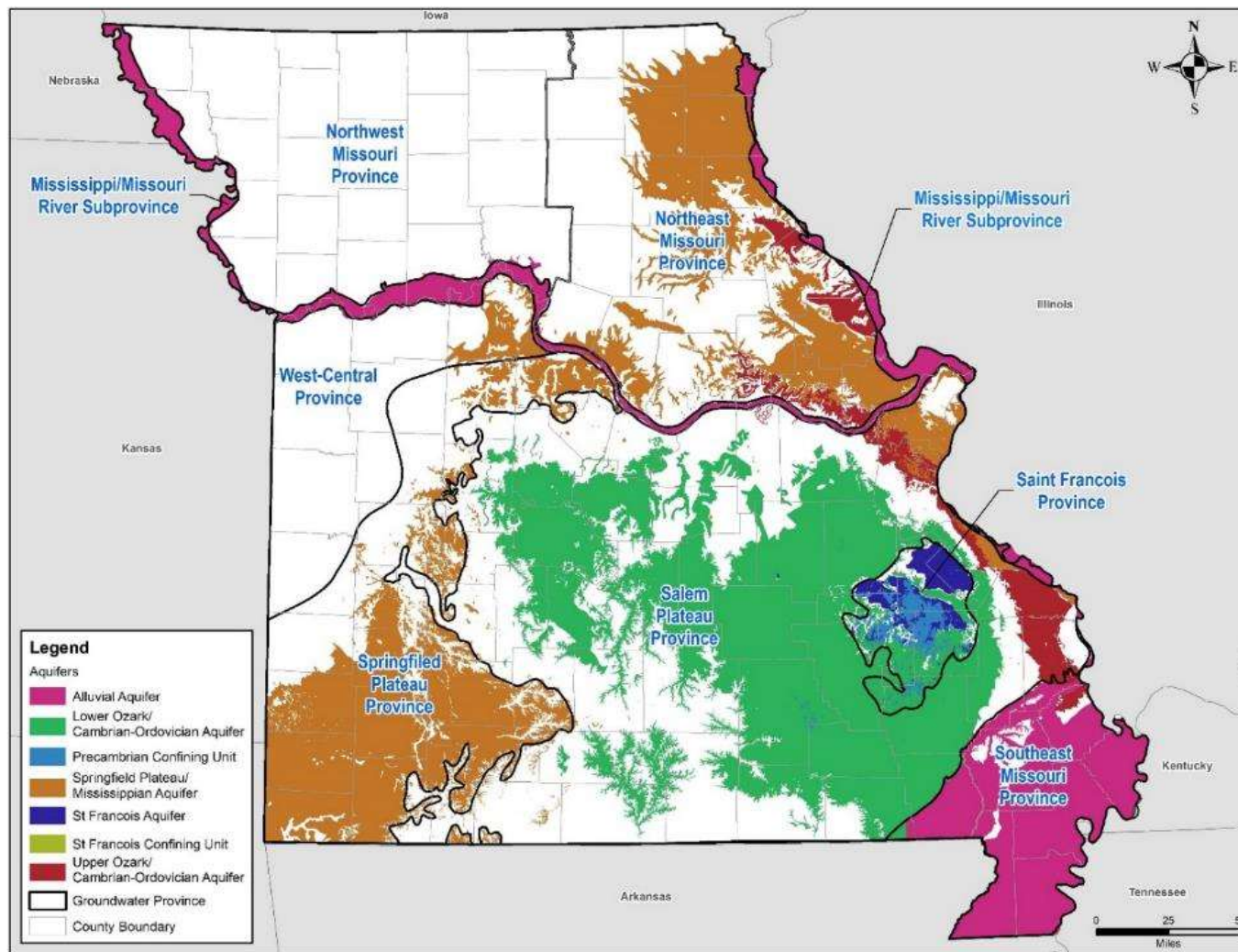


Groundwater Quality

- Statewide Groundwater Discussion
 - Uses
 - Monitoring
 - Issues/concerns
 - Water supply



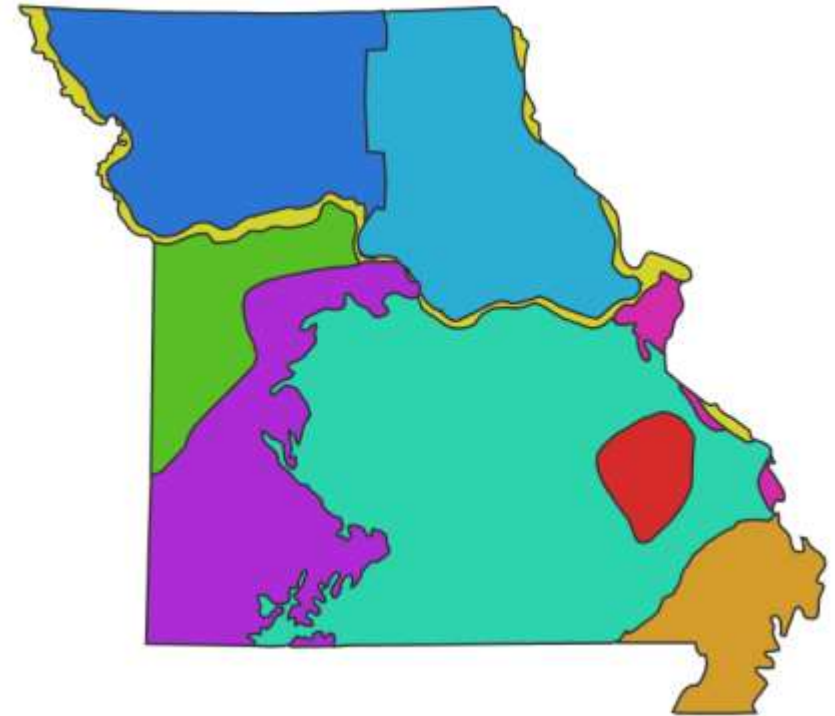
Major Groundwater Formations



Source: USACE, USGS and ESRI

Groundwater Quality

- Province-Level Discussion
 - Regional variation in groundwater uses and concerns
 - Data availability by region
- Temporal Trends
 - Changes in groundwater use and quality over time
 - Emerging issues
 - Data limitations



<https://dnr.mo.gov/geology/wrc/groundwater/>

Emerging Issues

- What's on the Regulatory Horizon?
 - Nutrient criteria
 - Bacteria
 - Ammonia
 - Sulfate
 - Others
- Emerging Contaminants
 - In both surface water and groundwater
 - Treatment implications
- Potential Future Impacts to Water Supply
 - Treatment costs
 - Infrastructure needs
 - Viability of residential drinking water wells



Conclusions and Recommendations

- Key Issues
 - Potential WQ impacts to water supply
 - Trends over time
- Changes since 1998 WQ Assessment (WR₄₇)
 - New and emerging issues
 - Continuing areas of concern
- Recommendations
 - Monitoring programs
 - Water source prioritization for protection and restoration



Next Steps

- Trend analysis for additional sites
 - Site identification
 - Data limitations
 - Areas of concern
- Prioritization by watershed
 - Impairments
 - Supply uses and needs
 - Projections and trends
- Report development



Public Comments



Thank You